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AVIATION

MAY 1947
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IN THIS ISSUE

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Special 16-page report for design, production, and maintenance men on standard and special components essential to efficient aircraft construction and operation.

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Comprehensive report by McGraw-Hill's economists covering America's needs and resources over next decade... Plus a thorough analysis of helicopter construction and operating costs... Plus power-space-density method of calculating passenger-mile costs.

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TRANSONIC SPEED DESIGNING

How Douglas, Navy, and NACA formed three-way team to create D-558 Skystreak to probe unknown range.

★

INTEGRAL TANKS IN CV-240

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AVIATION

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Volume 46 • No. 5

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Third Rate—That's U.S.A.

How do you like being a citizen of a third rate air power nation?"

Every American might well ask himself that question. And then ask it of his Congressman. For only by facing the fact that we don't like being third rate can we hope to change a position that day by day becomes more and more untenable.

Just two years ago this month, when the Germans admitted *alles kaput*, these United States had the greatest air force in the world. Yet in just 24 months that air force has been allowed to disintegrate to the point that we now have less strength in the air than either Great Britain or Soviet Russia.

Third place is not the place for the United States—in the air or any other field.

What can we do about it? Two things:

First, establish a national air power policy. Establish that policy in the light of UN's still feeble, oft-veto'd attempts to create a decent world. Establish that policy in the light of the painfully slow, constantly blocked efforts of the Big Four Council. Establish that policy in the light of the country's doctrine designed to give all the peoples of the world the right to free elections.

Second—and only after establishing an air power policy—complete the armed forces merger so that the best possible air weapons can be purchased for the least possible money, and in the shortest possible space of priceless time.

Taking these two steps—neither impossible for a courageous Congress—will allow the military to make some sensible, long range plans and allocate appropriations accordingly. It will permit the nation's manufacturers to make comparable plans, to keep their research and design organizations alive, to keep at least a nucleus of production groups in being—to develop the aircraft with which the United States can be sure, if the need arises, of control of the skies.

Without that control assured, we are in no position to do much talking, except, perhaps, to ask ourselves, "How do you like being a citizen of a third rate air power nation?"

Simple—But Costly and Necessary

If politics and diplomacy during the past year haven't proved the need for a long range program of aeronautical research and development, advent of the jet engine has.

Up to World War II we had one type of aircraft power plant—the reciprocating engine. But now, with men sticking airplane noses into the transonic region to open new speed ranges, it becomes plain that efficient military and commercial operations will require some six different types of power plants.

We will need, at least for a transition period, the old reliable up and down job, compounded with exhaust driven turbines to get better high altitude performance. We will need turboprops, turbojets, turboramjets, ramjets and, finally, rockets.

Basically, the jet engine is a simple machine. But it involves the engineer in widely varying sciences—new phases of aerodynamics, of metallurgy, of fuel technology—that make design and production of a new engine a highly complicated and expensive job. Creating jet engines is, and will be for some time, a very inexact science, one requiring expenditures of vast sums of money.

The aircraft industry, having kept its profits to about 2% of sales volume during the war, is spending what little it can from today's hand-to mouth existence.

No more reasonable insurance premium for the country's security is available today than money invested in this industry to continue the swift progress it has made with this new means of propulsion.

On the Lighter Side—

Anent the need for real sales efforts, we heard about a personal plane manufacturer who called his employees together and, with great fanfare, announced that the company wanted to help everyone of them boost private flying. To do this, he announced with enthusiastic pride, the company would let every single employee buy one of its planes at cost.

Next day, one of the older foremen came to the president's office and reported, "We don't like this plan of yours to buy our planes at cost."

"Why not?" asked the flabbergasted executive.

"Cost," replied the foreman, "is just too darned high over list price."

—John Foster, Jr.

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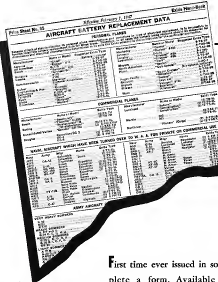

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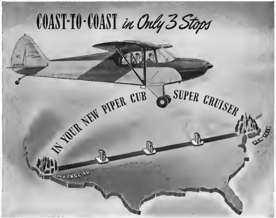

YES, you can fly the distance from Los Angeles to New York in just *three stops for gas* when you own a new Piper Cub Super Cruiser! With its 38-gallon gas capacity, this easy-to-fly personal plane will take you more than 600 miles without refueling Think of flying from Denver to Boston in *two* stops . . . New York to Miami in *one* stop . . . Minneapolis to New Orleans in *one* stop Or from your home to any place within 600 miles—non-stop! And if you fly at the economy cruising speed you can enjoy a maximum range of 700 miles!

This superior cruising range is but one of the many advantages you'll find in the Piper Cub Super Cruiser. It seats *three* passengers, one more than any other personal plane in its price field It has a muffler-equipped, 100-horsepower engine for a top speed of 115 miles per hour. As *standard equipment*, it brings you an auto-type electric starter and generator and a two-way, two-hand radio . . . features that add to the safety, convenience and enjoyment of your flying

See the Super Cruiser now at your dealer's . . . enjoy a free flight demonstration Ask him for the full-color Piper Cub literature and the new, revised edition of the popular book . . . *How to Fly a Piper Cub*. Remember—only Piper makes the Cub, that good, safe plane Piper Aircraft Corporation, Lock Haven, Penna , U S A . . . In Canada: Cub Aircraft Corporation, Ltd , Hamilton.

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Power. 1/2 hp.

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EEMCO ROTARY ACTUATOR

for opening camera hatch doors

A leading aircraft builder put it up to EEMCO to achieve almost instantaneous opening of the camera hatch doors on an important new military plane. This electric-motor-operated Rotary Actuator was EEMCO's answer. With a peak load output of only .55 hp. it develops torque of 275 inch-pounds on each shaft in an operating cycle of only one second.

The engineer will recognize that achievement of such performance is a noteworthy feat of engineering. It was accomplished in the face of severe installation and operating requirements and weight limitation. Incorporation of a radio noise interference filter was a must. "No over-travel" was another must, therefore positive travel limit switches are included . . . also magnetic clutch and brake. Close integration of components and extreme compactness are self-evident in the photograph above.

Here is a typical example of the complete design, development, and production service EEMCO gives manufacturers.

TECHNICAL DATA **Includes electric motor, magnetic clutch and brake, travel limit switches, and radio noise interference filter. Motor, 28 volt DC. Housings are magnesium castings. Weight, 7¾ lbs. Overall length, 13"; maximum height, 6-5/16".**

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What's New

In Products and Practices

. . . Key facts on the latest devices and equipment, tools and materials, product-and-practice literature. For additional data on any item, or copies of literature, simply fill in handy form (page 15), clip it to your letterhead and mail to AVIATION Reader's Service. There is no cost, no obligation

Airplane Reading Lamp 1

Peacetime version of wartime gun-sight lamp, announced as No G-B 1385 by **General Electric Co.**, Cleveland, Ohio, is small, reflectorized reading lamp for use in Boeing Stratocruiser. For about same wattage as aircraft lamps previously used, this 20w. unit is said to provide almost ten times as much illumination over reading area. Most of light is confined to a 20-in. dia area 3 ft. from lamp, and although it avoids sharp cut-off of beam, light tapers off rapidly around edge to give enough light for one passenger to read without disturbing other passengers. Because light is recessed into ceiling or above window, lamp avoids glare in eyes of other passengers It operates on 28v Outside length is 2⅝ in., rated life is 300 hr.

"Rigidized" Aluminum 2

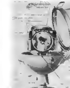
Announced by **Rigid-Tex Corp.**, Buffalo, is "rigidizing" process for mass production of variety of design-strengthened texturized-finished metal in which metal is distributed throughout cross-section and away from neutral axis to give patterned effects and to increase impact and deflection strengths. Photo depicts use of such metal by Glenn L. Martin Co in treads of new aircraft ramp Pattern variety permits choice to meet specific end needs In ramp, small-diamond configuration was used to give non-directional antiskid property to surface without need for weighty, cast stair treads. Company states any metal can be processed in strip or sheet form for blanking or further fabrication

Dual-Purpose Loading Truck. 3

Featuring ball bearing "bread roller" replacing conventional wheels, new hand truck is announced by **Air Associates, Inc**, Teterboro, N J Roller is stated not to catch in plane floor corrugations or wear grooves in floor coverings Truck can also be used as a ladder from ground to hatch of a DC-3 Weighing 6 lb and supporting a 1 000 lb load, it can be flown with cargo for use in loading, unloading, and giving access to ground

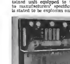
Rotating Aircraft Beacon 4

Mounted on either poles or roof tops and designed to meet service requirements of smaller airports, new rotating beacon made by **Airport Lighting Div., Line Material Co.**, East Stroudsburg Pa., consists of two standard 100w. sealed beam units producing 200 000 cp on rated voltage with a lamp life of 500 hr Under normal clear weather conditions, conventional operation at 85% voltage provides 110,000 cp and lamp life of 4 000 hr. Taps on transformer allow 20% over-voltage, which can give 400,000 cp. for low visibility emergencies Unit has automatic-operating double set of sealed beam lamps to assure dependability of operation with tell-tale circuit to control tower indicating when operation is on spare lamps. An additional lamp enables beacon to be seen from above, serving both as a ceiling height indicator and locator beam. Sealed beam lights used are same as employed in aircraft landing lights Complete unit, including low speed motor, require 325w for operation Beacon has no exposed moving parts. It weighs about 75 lb



Cabin-Heater Test Machine 5

Designed to meet need for suitable test unit for aircraft heaters, cabin heater test machine, Model JH-1 is made by **Greer Hydraulics, Inc.**, Brooklyn, N Y Machine is self-contained unit equipped to test heaters to manufacturers' specifications Unit is stated to be explosion and fire-proof. Features Capacity up to 1,000 cfm air flow at 12 in. of water at 70 deg. and 1 800 rpm.; adapters to permit mounting various models of heaters, temperature and pressure indication by gages and manometers accurate to 2%, and pressure feed system to simulate actual operating conditions.



Dual Brake Kit 6

Now retailed to dealers by **Luscombe Airplane Corp.**, Dallas Tex., is kit including all necessary parts, together with a drawing and directions, for installation of set of brake pedals for right hand side of cabin of company's Silvaire planes Brake pedal assembly is an extension of standard left hand foot-brake system used on both models of Silvaire line Maker states any competent mechanic can handle installation

Code-Marking Tab 7

Method whereby a single wire-marker can be removed without disturbing remaining markers on card, is feature of new "E-Z Tab" wire markers made by **Western Lithograph Co.**, Los Angeles. Tab assists in three ways Marker will not stick to fingers, since there is no contact with adhesive, dirt and contamination is eliminated, assuring maximum adhesive contact, and tab provides 50% more leverage than fingers when binding final end of marker to wire

Engine Cylinder Leakage Gage. 8

Designed to reveal amount of compression leakage past valves rings, or gaskets compact portable tester offered by **Hillside Laboratories, Div. of Cities Service Oil Co.**, Hillside, N J., is equipped with quick-connect air supply fitting, 10-ft. hose terminating in trigger-operated expanding fitting for rapid attachment to cylinder spark-plug hole, and built-in valve to regulate pressure After device is connected to air supply of not less than 80 psi., cylinder fitting is inserted and expanded and regulator valve is adjusted to bring pressure gage indicator to set-point. Adjacent leakage gage indicates loss in psi (alternate scale available for cfm) Also furnished for testing accuracy of gage is check unit, comprising calibrated orifice or standard leak to which gage is connected (as to cylinder)

Aircraft Battery 9

Weighing 21½ lb and measuring 7⅞ x 5¼ x 7⅞ in., Model S 24 aircraft battery recently introduced by **Reading Batteries, Inc.**, Reading, Pa., is said to be smallest and most compact storage battery with full 24 amp-hr. capacity While it was specifically designed for small aircraft, it is useful wherever weight and space savings are important. It is non-spill and is said to have good cold capacity

Radar Altimeter Switch 10

Produced for use with radar type altimeters, new type electrically operated coaxial transfer switch, made by **Radio Corp. of America**, Camden, N J., makes possible use of a single pair of antennas for operation of two

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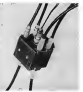
United States Steel Export Company, New York
UNITED STATES STEEL

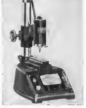
separate radar altimeters Unit (RCA type AVA-68) is a double-pole, double-throw coaxial device which can be operated from any remote position in aircraft. A two-wire power cable is used to connect AVA-68 switch assembly to a conventional toggle switch in cockpit Flip of toggle switch causes rotor mechanism in transfer switch to make electrical connection



between antennas and desired altimeter, at same time turning off unused altimeter automatically. UHF portions of switch contacts are of a snap action wiping type, with corrosion free surfaces. Switch can also be used with any other electronic equipment employing a 52-ohm coaxial line

Comparator Gage 11

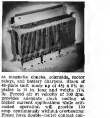
Operating without use of vacuum tubes or other components having limited life, new comparator gage of electromagnetic type is marketed by **Metron Instrument Co.**, Denver There are three models, calibrated in either English or metric units. Each gage has four ranges of magnification, selected by means of range switches so that a



single gage is suitable for a wide range of gaging applications from checking gage blocks to production inspection of machined parts Model 10 has a gaging range from 1 millionth to 4 ten-thousandths in., Model 20 from 10 millionths to 5 thousandths in and Model 30 from ½ a ten-thousandth to 20 thousandths in. Spindle pressure is adjustable and calibrated from 4 oz to 2½ lb and for versatile application head can be rotated at any angle about column or in vertical plane. Gage has two moving parts Spindle, which is supported in flexure, and pointer which is mounted on jewel pivots Line of available accessories includes large anvils, stops, flat tips, overhang supports, and V anvils.

Selenium Rectifier 12

Incorporating a flexibility of plate arrangement permitting stacks to be designed with any number of plates required to do a specific job, new heavy power selenium rectifiers, suitable for use in aircraft equipment, have been developed by **Federal Telephone & Radio Corp.**, Newark, N J They also feature improved electrical space and weight efficiencies and an easy method of mounting with simplified a.c and d c bus connections. Representative is 48-plate three-phase bridge-connected rectifier model furnishing 200 amp at 30v. d.c with plates connected in parallel Same number of plates, differently arranged can be made to produce other combinations of voltage and current. By connecting plates of each arm in series or in series-parallel, output can be changed to 240v 25 amp, or 120v 50 amp, for operation of such apparatus



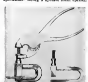
as magnetic chucks, solenoids, motor relays, and battery chargers. Stack of 48-plate unit made up of 4½ x 6⅜ in plates is 15 in. long and weighs 17¾ lb. Forced air at velocity of 200 fpm provides adequate stack cooling at higher current applications while self-cooled operation will provide 100 amp continuously without overheating Plates have double-center contact construction providing two current pickup points on each side, and they are said to withstand 26v a.c. back voltage

Metal Cleaner 13

Known as "Turco Transpo" new non-flammable cold tank cleaner made by **Turco Products, Inc.**, Los Angeles, is reported to be faster and more thorough in stripping of carbon, paint, varnish, adhesive dirt, oil and grease from aircraft engines and parts It is designed for operation at room temperatures, being most effective and economical at 65 to 85 deg Cleaner is virtually odorless through use of a liquid seal, which also protects life of compound It is stated to be non-corrosive to aluminum, magnesium cadmium plate steel, zinc, cast iron, and tin plate

Spring Tension Clamp.........14

Developed by **Aircraft Tools, Inc.**, Los Angeles, special spring tension clamp is effective for wood, plastic, or metal fabrication, template layout and wherever uniform pressure and speed of applying and releasing are vital factors Applicable with either pliers or gun, outstanding advantage stated is uniformity of pressure insured by eliminating hand tightening operation. Using a special steel spring,



clamp may be adjusted to secure up to 70 lb pressure. Pressure up to 100 lb may be had by using larger capacity spring Available in three standard sizes, clamps may also be ordered in special dimensions to meet job requirements Smallest standard clamp has Zamak yoke that will take pressures up to 500 lb This model may also be ordered with steel yoke which is standard with other two sizes

Metal Scour Cloth. 15

Made of solid high nickel alloy wire free from copper or iron content "Nickltex", a new all nickel scour cloth recently developed by **Metal Textile Corp.**, Orange, N J., is seen useful for numerous aircraft shop jobs Cleaner differs from steel and other metallic wools in that it is knitted into cylindrical form of a sleeve and is made in an endless chain without loose ends. Maker says it will not unravel or splinter and will not leave metallic particles on surface of equipment being cleaned. It is knitted of flattened wire which is positioned substantially at right angles to plane of cloth to provide maximum cleaning efficiency Open mesh construction permits free passage of water or other solvents for rinsing and cleansing purposes.

Material-Handling Trucks 16

Offered in three sizes, new aluminum-made material handling trucks have been introduced by **California Pallet Div., Tubey International Co.**, Los Angeles. Weight range is from 68 lb for a 24 x 48 in truck with 8-in wheels to 130 lb for 36 x 72 in. model with 12 in wheels Maker rates easy rolling load at 2,000 to 5 000 lb for all models, depending on caster size. Truck bed, made of high-tensile aluminum alloy extrusions is flexible so load is always supported on four wheels, regardless of rough floors. All trucks are equipped with heavy duty wheels with sealed lubrication Wheels are equipped with Timken thrust and roller bearings. Shakeproof king pin Elastic Stop Nuts, and cured-on solid rubber tires

One handle is standard equipment, but special handles or drags are available, as well as automatic couplings for tractors There are double hasps at each end for handles Trucks are stated to be adapted for use with trackless trains.

Decarbonizing Agent 17

Developed to remove high temperature carbon deposits from aluminum alloy aircraft pistons is "Lix-Sol", new hard-carbon solvent made by **Coburn**

(Turn to page 128)

AVIATION READER'S SERVICE — MAY 1947

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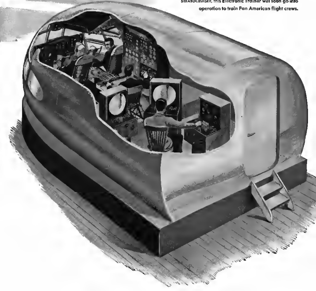
Curtiss-Wright Electronic Trainer

CUT-AWAY VIEW OF THE CURTISS-WRIGHT ELECTRONIC TRAINER FOR PAN AMERICAN WORLD AIRWAYS

Built to the specifications of Pan American, and reproducing the flight station and performance characteristics of the BOEING STRATOCRUISER, this Electronic Trainer will soon go into operation to train Pan American flight crews.



Conceived by Dr. R. C. Dehmel and developed after years of research and engineering by Curtiss-Wright, the electronic trainer offers the most complete training equipment available to airline operators.

Engineered and built to rigorous specifications it duplicates the flight stations of new airliners to exact detail. The trainer "flies" like an airplane simulating accurately the airliners' flight performance. Engine starting procedure is the same. All instruments react as in flight and the feel of all controls is realistic. Noises of the actual airplane are reproduced.

It simulates accurately and automatically all existing radio-navigational aids Unusual flight conditions can be simulated without danger to crew—failure of one or more engines in takeoff or in flight—failure of control boost, etc.

Extensive service tests have proved that the Electronic Trainer can be operated at unusually low maintenance costs.

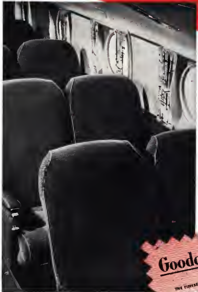
Backed by the Oldest Names in Aviation, the Curtiss-Wright Electronic Trainer contributes to more thorough flight training—reduces training flight time and costs—avoids unnecessary tie-up of flight equipment for training purposes.

A PRODUCT OF

PROPELLER DIVISION CURTISS-WRIGHT CALDWELL, NEW JERSEY

FIRST IN FLIGHT

*Velmo **TAKES** punishment
... **GIVES** comfort



Goodall weaves special lightweight *Velmo* upholstery exactly for the performance air lines require. Toughness that stands up under brutal punishment. Easy cleanability for low-cost maintenance. Softness for a "cradled comfort" ride. And beauty of color, design and texture to go with modern plane interiors. In the give-and-take of today's air line operation, you'll be ahead with Goodall *Blended-for-Performance* Fabrics.

**Velmo* REG. U. S. PAT. OFF. is the name of the superior quality transportation fabrics *Blended-for-Performance* by Goodall

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Laboratory tests of sample panels, for tautness and other properties, are but symbols of that long-established and unvarying standard of quality which characterizes Berryloid Aircraft Finishes. ⁅ As the outstanding producer of wartime aviation finishes during two world wars, Berry Brothers acquired invaluable experience and knowledge in the development and application of such finishes, and all of this highly specialized knowledge is now available to peacetime production and maintenance customers. ⁅ For real quality, dependability and uniformity, specify Berryloid. Those interested in Berry Brothers materials for refinishing are asked to call or write any distributor, including all Air Associates offices.

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A Federal Ball Bearing's long, friction free life is equal to the sum of these parts:

1 Balls uniformly spherical within .000025"... not varying in diameter more than .00005" in any bearing.
2. Through-hardened races concentric with each other to prevent run out—whatever the r.p.m.
3 Sides of rings parallel to each other and the ball track.
4 Ball tracks ground to chatter-free finish and just the right radius.
5 Bores cylindrical, not tapered or bellmouthed.

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Several major units—each an outstanding engineering achievement—are combined into a single system which meets all air conditioning needs of modern high speed, high-altitude passenger transports

By integrating units of suitable capacities into *complete, specialized systems,* AiResearch solves a major problem for designers of new aircraft Not only are all parts, controls and accessories obtainable from a single source, but AiResearch air conditioning experts are available to analyze special problems and adapt the equipment to meet particular needs.

All AiResearch 'Cabin Comfort' systems, whether for jet fighters or multi-engine transports, are distinguished by *high performance* in relation to size and weight, proven efficiency and important safety factors Careful consideration has been given to ease of installation and economy of maintenance under operating conditions

AiResearch leadership in the field of aircraft air conditioning and cabin pressurization is based on seven years of pioneering research and production Call upon this unique background of skill and experience to help solve *your* AIRCRAFT air conditioning problems AiResearch Manufacturing Company, Los Angeles 45, California.

TEMPERATURES IN THE SYSTEM UNDER EXTREME CONDITION OF 110° F

1. Ambient air enters at 110° F.
2. Leaves supercharger at 270° F.
3. Cooled in refrigeration unit to 40° F.
4. Moisture removed in water separator.
5. Air enters cabin, maintaining cabin temperature at 75° F

(System pictured above has been simplified for clearness.)

AiResearch 'Cabin Comfort' equipment conditions the newest Lockheed Constellation and is being furnished for new planes of Consolidated Vultee, Douglas, Boeing, North American, Republic and Northrop.

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DIVISION OF
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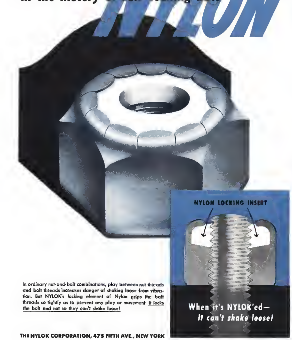
ANNOUNCING *the greatest advance in the history of self-locking nuts*

NYLON LOCK-NUTS

so superior that we believe they will render all other nuts <u>obsolete</u>!



In ordinary nut-and-bolt combinations, play between nut threads and bolt threads increases danger of shaking loose from vibration. But NYLOK's locking element of Nylon grips the bolt threads so tightly as to prevent any play or movement. <u>It locks the bolt and nut so they can't shake loose!</u>

THE NYLOK CORPORATION, 475 FIFTH AVE., NEW YORK

A new self-locking nut has been created, with Nylon as the locking element. It's called the Nylok Nut, and it's made by the Nylok Corporation, 475 Fifth Avenue, New York City.

". . . former nuts not good enough"

DURING THE WAR, under the name of The Fibre Lock Nut Co., we produced hundreds of millions of nuts, using fibre as the self-locking element. As fibre nuts these were, we believe, the finest that could be made but they had definite limitations which made us seek a better self-locking element.

Service experience impelled us to hunt for a locking element which would be an improvement and these experiments proved to us that

". . . Nylon is Superior"

AND IS BETTER IN EVERY CHARACTERISTIC

Nylon moisture absorption is practically nil.

Because of this it will not distort in freezing temperatures and in a drying atmosphere it will not shrink away from the bolt thread, as other non-metallic locking elements do with resultant loss of locking torque.

". . . resilient . . . re-usable"

Nylok nuts after 200 installations and removals still surpass Army and Navy torque requirements specified for the first removal.

Nylon has a tendency to return to its original shape. Nylok nuts have been put on bolts and taken off many times in one day. The following day it was found that the torque was considerably higher than on the last removals the previous day—showing that Nylon tends to return to its original shape

". . . above all others"

Experiment after experiment kept pointing to Nylon as the ideal locking element, above all others.

It had high resistance to esters, ketones, alcohols, weak acids and other chemicals that it might expect to meet—such as boiling 40% caustic soda solution.

It was unaffected by age or cold.

It offered low initial "on-torque" and a minimum of variation in torque characteristics between nuts.

And so on . . . through point after point of superiority over all the other non-metallic locking elements.

". . . it's ready now"

So we turned over our production, 100%, to the making of nuts with *Nylon*, rather than fibre, as the locking element. We called the nut Nylok, and it's ready now . . . ready to become a new measure of safety, efficiency and economy in your manufacture.

NYLOK

The Nut with the Self-locking element of NYLON from **DU PONT**

THE NYLOK CORPORATION, 475 FIFTH AVE., NEW YORK

THE AVIATION NEWS

» U. S. air forces must be ready—Gen. Eisenhower told the National Press Club in Washington, for any emergency. What worries the General and many others is rapid disintegration of skills and equipment of AAF and Navy, and the fact that both Russia and Britain are backing air powers that would exceed U. S. forces, which are cut to 55 active groups by President's budget and would be down to 35 by further Congressional trim. Congress alone is responsible for the outcome.

» Air power chiefly depends—upon an aircraft industry in being, and on operating skill. Annual reports for 1946 show most manufacturers in need of contracts to keep alive. Nothing but appropriations can make those contracts possible, and pay for training.

» While Army-Navy merger hangs fire—AAF, still tied to Army, is seriously handicapped in its battle against budget cuts. For reasons not yet clear, Army knuckled to Navy pressure and accepted the bill before Congress—which creates no real merger, merely stacks a cabinet office atop the pyramid. Net result is an "independent" air force, but with all the old potentialities for obstructive bickering.

» U. S. has no air policy—many complain. But it is now seeking unity of action, through such measures as (1) Sen. McMahon's bill to create a 9-man temporary air policy board, now before Senate committee, (2) a National Aviation Council, proposed by Rep. Hinshaw and backed by AAF, to succeed the Interdepartmental Air Co-ordinating Committee, which has been trying to blueprint a federal domestic and overseas program; or (3) some other policy group patterned after the old Morrow Board.

» American leadership—on world airways is stronger than anti-competition forces picture it. However, foreign lines are carrying an increasing share of total traffic. In the long run, if foreigners can match the U. S. in knowhow, we'll have to battle their low costs, as we did on surface shipping—and we lost.

» Community company—to operate U. S. overseas airlines, is before Congress again in a bill by Sen. Brewster, modeled on former McCarran bill. Pan Am favors it but is pushing merger with TWA first, which might give PAA the domestic routes it wants. Chosen instrument might pass this time, but Truman, like Roosevelt, is opposed, and his probable veto could not be overcome. Possible compromise is two or three community companies, which would provide competition and let all domestic lines share in overseas enterprise.

» Airline accident publicity—subsided when ATA in excellent advertising campaign laid operator's problems frankly before public. Strangely, public had ignored statistical safety record and lumped together all military, foreign, and nonsched accidents. But the bad press forced Congress' attention to need for safety funds, and made operators buckle down.

» More safety funds asked by President—total $22,532,000, include $4m (million) for high intensity approach lights, $3.59m for communications high frequency, $3.74m for 40 GCA sets; $1.04m for more ILS. Electronic engineers say dispute over ILS vs. GCA is wasted time; they will exhaust possibilities of both, plus the Sperry system. United is readying an elaborate ILS pilot training program.

» Third approach system—traffic and aviation control, is being advanced by Sperry toward early military and commercial use. Main features: (1) Electronic pilot for hookup with gyro pilot; (2) automatic (electronic) approach control, which uses either ILS or GCA approach ranges, (3) microwave instead of CAA VHF on local approach ranges, for more sharpness and stability. In addition, the Sperry program calls for omni-directional beacon that gives distance measuring, altitude sorting, and simultaneous facsimile map transmission.

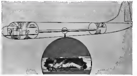
» Shape of airways to come—for heavier traffic, on precise schedule, in all weather, with increased safety, are charted by ATA. Leading features: Multiple runways, automatic time blocks, with radar plane position indication to pilots and ground controllers; cockpit instrument information integrated on a single indicator, giving position of plane, direction and distance from range station, altitude, and track to destination. Block signal will flash red when space ahead is occupied, green when clear. ATA plan is must reading for all airmen.

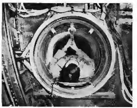
» Two more on "Washington merry-go-round"—Examiners recommend certification of Sam Solomon's Atlantic Airlines "Day Coach" service, also Colonial, on the heavy traffic drag between New York and the Capital. Solomon would cut rates to 3.5¢ by eliminating plush bottom extras. If CAB approves, that'll make four operators on the run, counting Eastern and American. Examiners called for additional extensions in the populous northeast by a half dozen other operators.

» But all is not well—Amid reverses that crowded five scheduled operators close to bankruptcy, and cries for more mail subsidies, CAB decided to re-examine need for activating recently-granted C&S Houston-Havana and

HERE'S H I LIGHT

One of high-intensity lights recently installed at Moffett Field, Cal., for allowing greater safety in night landings. Built by Line Materials Co. Airport Lighting Div. of East Stroudsburg, Penna., each unit is capable of 40,000 cp. Pathway of these lights will enable pilots to fix their positions while landing, since visual-guide "staircase" formation is employed in arranging lights. (Acme photo)





SUPERBOMBER'S "AIRBORNE SUBWAY"

Because of XB-36's enormous size, Convair engineers devised this "railway" system to enable crew members to get from one pressurized compartment to another with minimum effort. Transfer is sped by a four-wheel scooter, crewman riding it in supine position and propelling himself hand-over-hand along cable attached to tunnel's roof. Pressurized magnesium tube is 2 ft in dia and 85 ft. long. (International photos)

Havana-Caracas routes; Western Air Lines, seeking refinancing, cut in half its orders for DC-6s and Convair 240s; Colonial successfully sold 150,000 shares common, but at a high cost; airline officials sold their holdings at a new high rate at the year-end; CAB started a probe of Colonial and Northeast to determine their need for subsidy assistance; TWA, in addition to a $10,000,000 loan, called on CAB for millions in retroactive mail pay.

» **Fares 10% up**—After weathering the war price spiral with capacity loads, low selling costs, and contract income, airlines weakened as travel slackened and got from CAB 10% across-the-board passenger hike. Rather than let CAB take precedental initiative, airlines agreed to the request, over opposition that quickly gave in. But some still felt they were pricing themselves out of the market and seriously doubted whether the hike will net them $25,000,000 additional annual revenue.

» **Airfreight yardstick**—is Slick Airways, country's largest freighter, which celebrates its first anniversary and sets out to complete a 2-yr. test program. Goal for March is 2,750,000 revenue ton-miles, compared with just over 2,000,000 in November. Management thinks its ten C-46s can break even at 75% load, 10 hr. plane day, and an average rate of 13¢ per ton-mile.

» **Did they wait too long?**—For a decade, lightplane builders have shown little enthusiasm for most government-sponsored research for improved utility. Now, facing a money pinch, they meet with CAA for exploratory talks—just as Congress is cooling off with economy cramps. But NACA can divert some research effort to private aviation, and has already tested small-diameter fan propellers for noise curtailment. Manufacturers at least can tell the courts, answering community noise damage suits, that they have started work on the problem.

» **Crosswind swivel landing**—practically forced upon lightplane industry by CAA with John Geisse as chief plugger, is picking up interest, may vastly enhance private aviation through use of single-strip fields. Goodyear's new caster wheel has kingpin inside hub, making the modification easy, no interference with retracting. Fairchild pin is outside. Cross landing in high wind is simple with either type. Geisse, still retained by CAA, is castering a Beech.

—Blaine Stubblefield

WORLDATA

CANADA—TCA began using six DC-4M North Star aircraft built by Canadair, Ltd., which is making a total of 20 for the line at $660,000 each and another 24 for RCAF at $630,000 each. . . . One of largest Canadian airports is now under construction at Toronto—deHavilland airport, which was expanded during war to take Mosquitos and B-29s. Government will own and operate this port for RCAF. . . . Nine weather stations are being established above Arctic Circle in cooperation with U. S. to overcome flying weather "blind spot" and to obtain data for polar air routes. Farthest north station is 600 mi. south of Pole on west coast of Ellesmere Island.

ENGLAND—New furor was caused by plan to buy twelve Constellation airframes, which would be fitted with Centaurus engines. Main reason for move seems to be disappointing pay load and performance of Tudor II. Meantime, Avro reported six new versions of Tudor, including Model VIII bearing Nene power plants. . . . Percival is building prototype P-50 Prince feederliner, eight-passenger craft powered by two Alvis Leonides 505 hp. engines.

FRANCE—Voisin has developed two canard type craft—MP-200 four-seater with two 120-hp. engines, 143-mph. top speed, and low landing speed of 19 mph., and MP-1000, 646-mph. racer with 2,000-hp. engine.

CHINA—Revamp of CNAC operations was placed in hands of E. M. Allison, former Boeing test pilot, after company announced postponement of international services until domestic operations were smoothed out. . . . Government reported plans for construction of 20,000 mi. of airways, covering 49 airports along main trade routes.

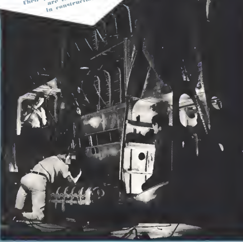
CHILE—Word came of plans by Chilean company for trans-Pacific operation to Sydney via Easter Island.

MEXICO—Reorganization of Aero Transportes SA was completed, with Senor O'Farrill as president and Fred Word as general manager. Company operates five 247s and two DC-3As from Monterrey to Mexico City, Guadalajara, Torreon, and Eagle Pass. American citizens still hold a 55% interest in company.

AUSTRALIA—Trans Australia Airways is installing automatic radar distance-meter system on Sydney-Melbourne route. Unit in plane sends out pulses, which are returned by ground transponder beacons. Interval shows distance to beacon, and each beacon has own identification signal indicating its position on route. Dial in plane flashes beacon signal every minute. Designed by TAA engineers in cooperation with Council of Scientific & Industrial Research, system is considered "superior to anything produced in other countries." . . . TAA Gen. Mgr. Lester Brain, after visit to U. S., reports that American lines "have a few adequate airports—but standard of service, consideration to passengers, and efficiency of operation do not equal our Australian services."

FASTENERS FOR AIRCRAFT

Their precise design and high utility are foundation factors in construction progress



For design, production, and maintenance personnel, here are engineering features —not only of standard but also many special developments—of key components essential to the planning, manufacture, and operation of more efficient aircraft.

FASTENERS FOR AIRCRAFT

VITALLY IMPORTANT — but much too frequently taken for granted because of their small size and routine use — aircraft fasteners constitute the "mortar" joining the legion of structural and equipment components into the dependable whole.

Ingeniously designed and precisely fabricated in a comprehensive variety of sizes and shapes, these units — bolts, screws, nuts, rivets, and related hardware — find universal use in aircraft construction. Accordingly, these fasteners comprise a basic consideration for designers, production men, and maintenance crews.

With the advent of the initial impetus in aircraft development, manufacturers of this hardware were not complacent about their products. Realizing the importance of the high standard of material and finish requirements, they kept pace with the rapidly expanding plane industry and produced units which are outstanding examples of utility for both military and commercial craft designs.

And realizing the need for improvement in locking provisions, they developed new fasteners with unique integral safetying features. These units — extensively accepted by the industry — have proved their worth in all types of craft and have paid notable dividends in production programs and maintenance work.

The standardization program for basic aircraft components has resulted in a relative uniformity of high quality products, probably unexcelled in any other field. Responsible for this standardization, in the main, are such agencies as the AAF, BuAer, CAA, and NASC. Many other standards, such as SAE, have been drawn upon for utilization of basic data.

While not possible to incorporate details of all fasteners, information is presented here on representative types — to constitute a ready reference for design engineers, production expediters, and men in the field.

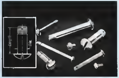
bolts, nuts, machine screws

1.

2.

1. Seen here are variety of aircraft bolts. Extensively used in aircraft components, unit is available with or without cotter pin hole, being used in latter instance with self locking nut or other nut properly safetied. For corrosion protection, steel bolts are cadmium plated, and aluminum alloy units are anodized. (Photos of bolts, nuts, and machine screws, courtesy of Air Associates.)

2. Eyebolt, as name implies, has eye head for use in such applications as attachment for fork end of turnbuckle assembly or cable shackle.



3.

4.

5.

6.

7.

8.

3. Clevis bolt has slotted head and is generally used in shear applications. Unit is also available with or without cotter pin hole. Clevis (flathead) pin (not shown) has unthreaded drilled end for safetying with cotter pin. Unit is installed with head up so that if cotter pin fails or works out, clevis pin will tend to remain in place.

4. Aircraft bolt with drilled head has three through holes to serve six head sides. Generally used as means of anchorage to tapped holes, unit is intended for safetying with lockwire.

5. Internal wrenching bolt (left) is high strength unit for limited wrench clearance applications; also permits smaller complementary fitting sizes. Flush head 100-deg close tolerance bolt is high shear unit adaptable for installations where little play is desired, as in control linkages.

6. Aircraft castle nut. Used in conjunction with drilled-end bolt, unit is safetied with cotter pin or lockwire. Multiple slot arrangement permits proper tension adjustment and correct alignment of slot and bolt hole.

7. Plain nut requires auxiliary locking device, such as check nut, lockwasher, etc.

8. Shear nut has approximately three complete threads below castellations, and is generally used in shear applications, as with clevis bolt.

GENERAL THREAD DATA

TYPES OF FITS AND USES

Class 1 (loose fit) — Recommended as commercial standard for tapped holes in small sizes only, and for rough work when ease of assembly is desirable and snugness of fit is unnecessary.

Class 2 (free fit) — Includes great bulk of screw thread work of ordinary quality finished and semi-finished bolts, nuts, etc.

Class 3 (medium fit) — Includes better grade of interchangeable screw thread work (adopted for general run of aircraft and engine work).

Class 4 (close fit) — Includes work requiring fine snug fit. In this classification, selective assembly of parts may be required.

SIZES AND THREADS PER INCH

National Fine Series (NF)

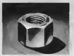
Size	4	5	6	8	10	1/4	5/16	3/8	7/16	1/2	9/16	5/8	3/4	7/8	1
Threads per inch	48	44	40	36	32	28	24	24	20	20	18	18	16	14	14

National Coarse Series (NC)

Size	4	5	6	8	10	1/4	5/16	3/8	7/16	1/2	9/16	5/8	3/4	7/8	1
Threads per inch	40	40	32	32	24	20	18	16	14	13	12	11	10	9	8

9.

10.



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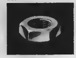
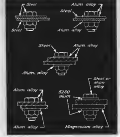




14.

12.

13.

9. Plain and slotted engine nuts are high strength units not easily deformed by wrenches.

10. Exhaust manifold nut is extra-high double chamfered rust- and heat-resistant brass unit.

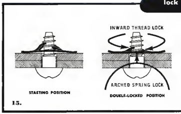
11. Check nut serves as auxiliary locking unit for plain nut.

12. Wing nut is intended for use where desired tightness is ordinarily obtained with use of fingers. One lobe carries hole for safetying with lockwire

13. Machine screws. Designations (left to right top): Round head, button, and 82 deg flat. Bottom: Fillister, drilled fillister, and washer head.

14. Bolt (or screw) and washer combinations for corrosion—resistance.

lock nuts



15.

15. Operating principle of Tinnerman sheet-spring self-locking Speed Nut—made to fit AN530 (Type Z) sheet metal screws—is shown in this illustration of flat type unit. Designed with free-running fit, lightweight nut spins over thread to starting position in which prongs are well arched. Two or three turns with screwdriver locks nut by reducing prong arch, forcing prongs deeper into thread and affording spring lock at nut base. Correct tightening torque is achieved when lowest prong is almost flush with base. Nut, shown in some of the many fabricated forms in accompanying illustrations, is intended for non-structural installations, and has wide variety of applications.

16. Twin type Speed Nut combines two units in single piece for attachments where fastening locations are grouped in pairs. Center hole is for riveting into blind location.

17. Push on type nut used on rivets or unthreaded studs in lightweight attachment such as for instruction plate, is applied with simple special tool for pressing into locked position. Tool is counterbored so that nut prongs can move freely. Pressure flattens nut, and with release of pressure, nut spring back forces prongs into stud

18. U-type Speed Nut holds self in screw receiving position in blind location. Unit, used where hole is close to edge, is intended to eliminate need for riveting nut plate at such location. Floating U-type nuts used with aluminum alloy retainer strips are substitute for heavier gang-channel nuts.

19. Performing same function as U-type nut, this J-type is used where full bearing on lower leg is unnecessary

20. For use on assembly with series of equidistant screw holes, this continuous nut strip is intended to provide added reinforcement. Unit is fabricated of spring steel or stainless steel for spotwelding

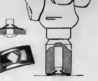
21. For attachment of installations such as hand hole cover and access doors, floating U- or J-type nuts are carried on circular aluminum retainer ring

22. Corner anchor nut seen here is designed for flush blind mounting with 100 deg head screw. Other anchor nuts include double lug, offset, angle, and floating (U-type) basket

23. Speed Nut for plywood. As seen in this sketch of end view, when driven into thick plywood, attaching legs are forced outward for permanent hold. In thin plywood, legs are peened over with backing plate. To compensate for hole misalignment, plain retainer unit may be fitted with U-type nut.

24. In this attachment of plywood to metal, nut with wide bearing surface spreads load, and special bushing with flared end for flush screw reinforces wood

16.



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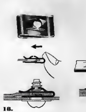

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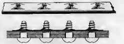

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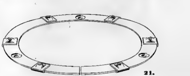

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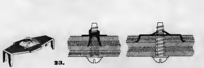

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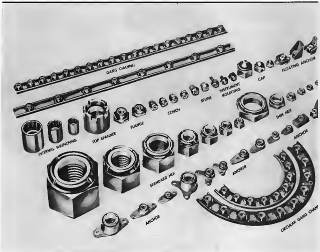
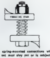


25.

25. Some forms of reusable Elastic Stop Nut. Feature is fiber locking collar, with hole smaller than bolt diameter. Collar resists bolt movement but yields to impression by bolt thread, thus forcing nut and bolt threads into firm pressure contact. Nuts are used for −80 to +250 deg F temperature range. Gang channel assembly (straight or curved blind nut mount) has nut flanges slidingly held under channel flanges. Nuts are spaced by dimpling, providing floating movement for lesser degree of alignment accuracy. Fastened by riveting through base channel assemblies are used for attachment of cover plates and access panels. Internal wrenching nut is cylindrical unit with rim broached internally to provide double hex internal socket. Shape and wrenching rim makes outside wrench clearance unnecessary, thus permitting reductions in dimensions and weight of associated parts. Unit is also used where limited clearances prevent using hex nuts. Top spanner has rim having six slots for spanner wrench or special plug wrench provided with dowels. Application is similar to internal wrenching nut. Flange nut is designed for tack welding in place generally with short tack at point of pair of oppositely located faces of hex. Clinch nut has knurled tapered hollow shank. Hole is put in attaching sheet, hole size being such that knurling penetrates material as nut is forced into hole. Spline nut has knurled cylindrical shank as extension of nut main body. Designed for blind mountings in relatively thick metal sections, nut is assembled with force fit in soft metal castings such as magnesium or aluminum, splines cutting own seats. Another method is to contract shank via refrigeration. For installation in material harder than nut body, special unknurled shank unit is adaptable. Here splines are broached in nut hole to cut seats in the unknurled shank of nut, when it is forced into hole. Instrument mounting nut has plain shank as extension of bolt hole. Shank is inserted in hole, and end of shank is swaged out or clinched over. Since shank is plain, assembly should preferably provide backing against hex flat to prevent turning. Particularly where longer shanks are used, hole diameter should be such that shank is supported by hole wall to avoid buckling during swaging operation. Cap nut is a regular unit with addition of a cap having a flange resting on top of locking collar. Nut rim is closed over locking collar and cap flange, making cap structurally part of nut. Floating basket anchor nut provides relative movement of nut and anchorage to permit ready insertion of bolt, for lesser degree of accuracy in alignment. Same principle governs right angle floating basket nut. Standard hex is used for all classes of bolted fastenings. Thin hex is used for shear loads, also light tensile loads. Anchor nut is fastened (as by riveting or welding) to one part of assembly, previous to bolting. Nut is most often used for blind mount. Various units described are manufactured by Elastic Stop Nut Corp. of America (Esna).

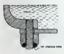
Wherever a vibrationproof bolted connection is desired



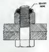
For spring-mounted connections where the nut must stay put or is subject to adjustment.

For rubber insulated and cushion mountings where the nut must not work up or down.

On make and break adjustment studs where accurate contact gaps are required

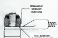


Where elimination of leakage past stud threads is necessary



Where it is desirable to protect bolt or stud threads from corroding elements

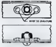
For bolted connections requiring predetermined play



On all electrical terminals subjected to vibration in transit or operation.

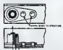
Where precision pre-stressing of bolts is required—for Elastic Stop nuts can be adjusted to exactly the wrench torque required and automatically lock in that position.

26.

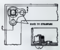


Type A 1 Two-lug anchor nut for regular blind mounted attachments.

Type A 2 Two lug anchor nut for flush blind mounted attachments.

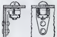


Type A-17 One-lug anchor nut for regular blind mounted attachments with limited edge space



Type A 5 Corner anchor nut for regular corner blind mounted attachments.

Type L Instrument mounting nut for mounting instruments on control panels



Type A-7 Right angle anchor nut for right-angle mounted attachments.

Type C Clinch nuts for blind mounted attachments

Type G-2 Gang channel for flush blind mounting

Type K Cap nuts for safety and appearance

Type D Spline for mountings in close quarters in relatively thick materials, such as flanges of castings.

26. Applications of Elastic Stop Nuts.

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27. This stamped sheet metal fastener — Prestole's Hex Lox—is spring lock nut combining functions of stop nut and lock washer In addition to constriction action at (A), binding action of two spring tongues at (B) affords tension under threads when tongues are forced down as nut is seated

28. Palnut, used extensively in conjunction with aircraft engine nuts, is single thread locknut stamped out of spring steel or other material Inner edge is slotted (except in small sizes) to form spring jaws for closing in to grip thread as device is tightened. Pressure of screw thread slightly flattens nut's coned center and force (A A) exerts spring tension to hold regular nut in place, while force (B B) grips threads, preventing bolt from backing out. Maximum holding force is obtained with between ¼ and ½ turn beyond finger tight position. Other types include Inverted (self locking), acorn, washer and special units.

29. Drake nut (top) is two piece combination—slotted lower member for fastening upper for locking—for installations where factors of size and weight are not of top importance. Contact between members is made on mating bevels, and flexible sections of lower member are compressed inwardly with tightening of locking member Maker is National Screw & Mfg Co. National's Dynamic (top center) is thin shear nut featuring diaphragm lock. Groove in top and recess in base provide resilient central section serving as diaphragm As nut is tightened, outward axial flexing action develops, affording locking pressure on upper flanks of nut threads and mating lower flanks of bolt threads National's Huglock (lower center) is formed with slotted tapered crown, so curved that six segments press inwardly against bolt and set up downward pressure, producing lock between load-carrying flanks of nut and bolt Nut grips bolt whether seated or not. Company's Marsden (bottom) has recessed bottom face affording narrow outer ring seating surface Upper part of nut is slotted to form six segments Seating pressure on rim of bottom face forces segments inward radially causing nut threads to align securely with mating bolt threads

30. Pinnacle nut incorporates non corrodible metal spring locking diaphragm, which is deflected up from normal straight position to grip bolt threads. Maker Simmonds Aerocessories, states unit may be used in applications involving temperatures up to 650 deg. F Flexibility of diaphragm is designed to afford lock on both high and low-limit bolts after large number of nut removals.

31. Nylon insert is feature of Nylock self-locking nuts seen at left and right. As bolt threads are impressed into insert, it sets up counterforce to grip threads and prevent nut from loosening Nut seen at center is a standard-height unit with Nylon locking plug to force bolt laterally against nut threads to take up axial play Black Nylon is used with NC thread white with NF Advantages claimed include high re usability, low moisture absorption cold resistance high elasticity (effective on minimum pitch diameter bolts) gasoline and oil resistance, and adequate heat resistance

32. Pem self-locking nut has insert of resilient laminated plastic Tension caused by resistance of insert to progress of bolt creates out-of-phase relationship between metal and plastic sections of nut thus eliminating axial play, to provide locking action Device is fabricated in various types, including hex, thin hex, anchor strip clinch, spline and instrument mounting nuts has re usability feature and is subject to 250 deg F temperature limitation Maker is Penn Engineering & Mfg Corp

33. Locking feature of Standard Pressed Steel's Unbrako internal wrenching nut comprises two vulcanized fiber plugs inserted through body, each contacting four bolt threads

34. Standard's Flexloc features one piece construction also high re usability Top portion has six radial slots providing equal number of flexible jaws to accommodate wide range of tolerances without substantial torque variation Jaw portion i d is slightly less than bolt o d and segments press against bolt.

35. Esna's high-temperature (1,000 deg F) self-locking nut (Type 2) is designed to meet operating conditions encountered on exhaust manifold systems, turbojet tailcones, etc Top part of nut is deformed inwardly to grip bolt. Made of modified 303 stainless steel, additional finish is engineered to prevent seizure and galling at high temperatures. Nut may be reused as low tolerance bolts after previous use as high tolerance units.

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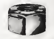

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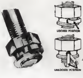

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36. Boots cage nut is designed for permanent fastening in plywood or plastics. Installation is accomplished with special clinch tool.

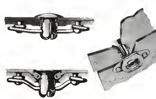
37. Boots all-metal heat-resistant self-locking reusable nut has top (locking) section with out of phase threads connected to bottom load-carrying section by integral spring member As bolt meets threads of top section spring member is extended to establish locking force Threads on load-carrying section press up, while those of locking member press down Types seen are Wing (top) Rol Top (center) and Bellows (bottom) Wing type is fabricated of sheet metal to incorporate weight saving factor along with required strength Variations of wing type include anchor nut, channel (straight or curved), floating and multiple anchor Manufacturer is Boots Aircraft Nut Corp.

38. Self Retaining nut is one piece slotted unit affording spring action for locking via deformed threads in top section Columbia Nut & Bolt Co is maker

39. Demonstration plate seen here illustrates use of Click retainer Spring element snaps into recesses on underside of anchor plate to hold nut (Elastic Stop Nut shown) or bolt securely in plate cut-out. Spring is easily removed for replacement of individual fastener Device eliminates necessity of drilling rivets of worn conventional nut plate to effect removal (Kaynar Mfg Co.)

40. Simmonds' dual-purpose safety nut has snap ring to engage one of series of longitudinal serrations in bolt thread With seven serrations on bolt, there are 14 locking positions per nut revolution Used without serrations in bolt thread, nut is tightened and locking ring snapped into locked position spring pressure providing stopping action. Locking ring is permanent part of out.

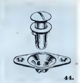
quick-fasteners

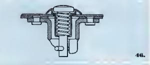


41. 42.

41. Dzus quick-acting fastener for removable or hinged panels operates on principle of spirally slotted rotatable stud engaging spring member so that secure lock is obtained with 90 deg stud rotation Unit compensates for variations in material thickness and corrects for misalignment. Stud head styles generally used in aircraft include oval flush, and wing Seen in sectional views (showing oval and flush heads) are half grommet to retain stud, and full grommet used in thin or soft materials or to provide wearing surface under stud the grommet being installed with special flaring tool Fastener may also be installed without grommet. Spring member is attached by riveting using AN rivet spacing according to size of installation.

42. Shakeproof's quick-fastener consists of three parts—spring unit stud and crosspin. After holes are prepared in sheets to be fastened spring unit is attached to inner sheet stud is placed through outer sheet hole and crosspin inserted with special pliers. With stud in spring unit ¼ turn locks sheets Stud heads are flush, oval, or wing





43. Shakeproof's snap-receptacle type (Q-Two) quick fastener. After stud is inserted through outer sheet hole, retainer washer is slipped over stud. Receptacle is slipped into prepared recesses adjacent to inner sheet hole, to complete assembly.

44. Quick lock self ejecting fastener has stud consisting of inner and outer housings. Inner housing (hollow) is integral with locking lugs and contains spring for ejectment and holding in locked position. Outer housing retains spring and inner housing as complete assembly. Locking ring, inserted between lugs and outer housing collar, is closed with ordinary pliers and gives permanent installation in sheet. For locking, two sheets are brought together so stud enters collar. Stud is then depressed against spring action and turned until it rides under cam surfaces of plate receptacle to lock in cam seat. Other receptacles include screw and adjustable types. Stud heads are flush, oval, and wing. Maker is Simmons Fastener Corp.

45. Camloc quick operating fastener has stud assembly comprising stud, crosspin, spring and spring cup in permanent relation. Receptacle is either rigid or floating type. Screwdriver action on stud causes crosspin to ride up dual cam rise and into detent. Head dam and end dam of detent prevent crosspin from rocking or overriding. Installation may be with or without grommet. Stud assembly is inserted with special pliers which squeeze stud head against spring cup.

46. For light attachments, this Camloc quick fastener has stud assembly complete with grommet (integral with spring cup). Spring can be compressed by finger pressure for stud insertion.

47. This Camloc latch fastener, seen installed on demonstration plate, is self-locking when attaching panel or door is closed; nose of latch (A) extending over striker plate of adjacent structure. Finger pressure on circular portion (B) releases latch to open panel.

48. Simmons' one piece Spring Lock fastener is self adjusting to compensate for various material thicknesses. Head construction assures one-direction rotation for locking or unlocking. Quarter turn puts initial twist in spring and another quarter turn locks fastener in place. Spring pressure pulls sheets together.

49. Chart of material uses for self tapping screws (courtesy Parker-Kalon Corp.).

KIND OF MATERIAL	TYPE OF SCREW: Type A	Type Z	Type Z (18-8 stainless steel)	HEX CAP	Type F	Type F (corrosion-resisting steel)	Type F-Z	Type U	Type 21
SHEET METAL .015" to .050" thick (Steel, Brass, Aluminum, Monel, etc.)					Not recommended	Not recommended		Not recommended	
SHEET STAINLESS STEEL .015" to .050" thick			Not recommended				Not recommended	Not recommended	Not recommended
SHEET METAL .050" to .200" thick (Steel, Brass, Aluminum, etc.)	Not recommended		Not recommended				Not recommended		Not recommended
STRUCTURAL STEEL .200" to ½" thick	Not recommended	Not recommended	Not recommended				Not recommended		Not recommended
CASTINGS (Aluminum, Magnesium, Zinc, Brass, Bronze, etc.)	Not recommended						Not recommended		Not recommended
CASTINGS (Grey Iron, Malleable Iron, Steel, etc.)	Not recommended	Not recommended	Not recommended	Not recommended		Not recommended	Not recommended		Not recommended
FORGINGS (Steel, Brass, Bronze, etc.)	Not recommended	Not recommended	Not recommended	Not recommended	Not recommended	Not recommended	Not recommended		Not recommended
PLASTICS: PHENOL FORMALDEHYDE — Molded: Bakelite, Durez, etc. Cast: Catalin, etc. Laminated: Formica, Textolite, etc.	Not recommended								Not recommended
PLASTICS: UREA FORMALDEHYDE — Molded: Plaskon, Beetle, etc.	Not recommended	Not recommended	Not recommended	Not recommended	Not recommended	Not recommended			Not recommended
PLASTICS: CELLULOSE ACETATES and CELLULOSE NITRATES. Tenite, Lumarith, Plastacele, Celluloid, Pyralin, etc.	Not recommended								Not recommended
PLASTICS: ACRYLATE and STYRENE RESINS — Lucite, Plexiglas, Styron, etc.	Not recommended								Not recommended
PLYWOOD, Resin Impregnated — Compreg, Pregwood, etc.									Not recommended
ASBESTOS and other compositions: Ebony Asbestos, Transite, Marinite, etc.					Not recommended	Not recommended		Not recommended	Not recommended

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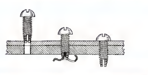
53.


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50. This shows how length of screw is measured with respect to various head types.

51. Phillips type recess shown in this sheet metal screw head is also available in machine screws. Design minimizes stress concentration in head. Special screwdriver point is self-centered in starting and affords secure driving.

52. Shakeproof's thread-cutting screws: Type 1 (left), for metal, has off-center cutting slot giving radial cutting edge and yielding section simulating action of tap. Type 2 (left center) has deep slot creating weak section, permitting slight collapse and relief to cutting edge. Other slot is behind centerline so that 70 deg cutting edge is presented—suitable for plastics and other soft materials. Type 9 (right center) has entering end intersected by series of flutes giving cutting edges and chip clearance cavities. Unit is intended for brittle metal and brittle plastics. Type 25 (right), for plastics has off-center slot presenting 70-deg cutting edge from which chips are deflected.

53. Action of Holtite Tap Screw. For start, pilot point gives straight alignment, and two cutting edges tap threads, with chips pushed ahead. (Continental Screw Co.)

54. Shakeproof's self-locking set screw has deeply slotted offset end. Offset edges spring inward to grip threads and exert resistance against backward movement.

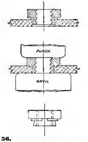
55. Unbrako self-locking set screw features knurled point. Similar unit is fabricated with knurled thread but without knurled point, for use where hard metal is engaged. (Standard Press Steel Co.)

threaded inserts

56. Penn self-clinching threaded steel insert is adaptable for sheet metal too thin for threading. Clinching ring under head squeezes sheet around shank back-tapered portion to secure fastener to sheet. Cut-out section on ring prevents insert from turning when screw is tightened. (Penn Engineering & Mfg Corp.)

57. Rosán threaded insert for soft metal, plastics, and wood has lock ring serrated inside and outside, engaging its inner teeth with mating serrated collar on insert. Ring outer teeth are broached into parent material at surface of counterbore, insert thus becoming permanent installation. For assembly, material is drilled, counterbored, and tapped, then insert is screwed flush with material surface and lock ring driven in. Unit is product of National Screw & Mfg. Co. and Bardwell & McAlister.

58. Heli-Coil stainless steel or phosphor bronze insert (left) for light metals and plastics, also used to replace stripped or worn threads or original threads (NC or NF) in units requiring frequent capscrew or stud removal. Unit is inserted with special tool which engages tang, then latter is broken off with blunt tool (unnecessary in blind holes). Aero-thread insert (right) for high fatigue loads functions similarly but is used with thread system consisting of truncated V in tapped hole and round valley in screw or stud. (Aircraft Screw Products Co.)



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58.

lockwashers, pre-assembled lockwashers and screws

59. Various lockwasher types seen are (left to right): External, for use with U. S. Standard hex nuts, and hex washer-head-, binding- and truss-head screws; internal, for SAE hex nuts, and round-, fillister-, and hex-head screws; countersunk, for flat and oval head screws; external-internal, for elongated holes, oversize clearance holes, metals with weak understructure, and wood; and dome type (also available with plain periphery), affording added spring tension feature, for use on semi-rough surfaces and wood. (Courtesy Shakeproof, Inc.)

60. Preassembled screw-and-lockwasher units. Washer is free to rotate but cannot come off. (Furnished by New England Screw Co., as Nescolok, and by Shakeproof Inc., as Sems. In addition to preassembled units, Continental Screw Co. fabricates washer as integral part of head, as Lock-Tite.)

61. Helical spring (split type) lockwasher is also available with screw member in preassembled unit.


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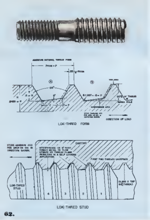

62.

locked-in studs

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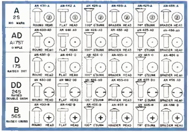
62. Principle of Lok-Thred stud (top) construction and action. In diagram at center heavy black line depicts Lok-Thred form superimposed on American National thread form indicated by dotted lines position (A) showing comparison in male thread of each Position (B) diagrams action as male Lok-Thred enters 60% American National thread tapped hole Metal from crest of female thread (indicated as interference area) is caused to flow along helix angle of the male thread filling void between flanks of two mating threads (indicated as void area) This creates positive seal and firmly anchors stud Illustration at bottom shows sealing and locking action that occurs as Lok-Thred stud is driven into tapped hole Reforming of crest of female thread begins at or before second thread and voids are filled starting with third or fourth thread. The 003-in. or more thread taper of stud increases interference and supplements flow of metal to produce increasingly firm anchor as stud is driven to depth desired (National Screw & Mfg Co.)

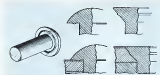
63. Rosán locked-in stud features lock ring similar to that of Rosán threaded insert previously described, rendering stud integral part of parent material. (National Screw & Mfg Co and Bardwell & McAllister)

rivets — standard and special

64.



64. Chart of various standard rivet types. Interpretation of coding, such as AN-442-AD-4-8 AN indicates Army and Navy specification 442, type of head AD, type of material 4, diameter in 32nds, and 8, length of rivet in 16ths Rivet 2S is shank marked when specified (Courtesy National Rivet & Mfg Co)



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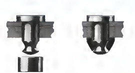
65. Integral sealing ring (hump) is feature of Cherry's Keg rivet. Deformed with driving, ring provides sufficient surplus material to fill irregularities in surface under rivet head. Unit was designed by Boeing personnel. (See page 103 June '46, AVIATION)

66. Used in assemblies where fluid tight joints are required, new sleeve rivet is standard aircraft aluminum alloy unit with shank covered by 004-in. dead soft aluminum tubing. Sleeve head is flared to match rivet head and tail end is peened to cover shank radius end. Sleeve flows under force of rivet expansion filling hole irregularities and bonding itself to sheet. Invention of Douglas Aircraft. unit is made by Vic Patushin Industries

67. Hi Shear rivet has heat treated alloy steel stud with head at one end and groove on other end in which aluminum alloy collar is engaged by deforming Special riveting tool forms high button upset and shears off excess material Device is made by National Screw & Mfg Co and Pheoll Mfg Co.

68. Huck Lockbolt combines advantages of bolt and rivet. Pin is inserted from back of work collar slipped on and special driving gun applied to grooves in pin projecting end. Gun squeezes work between collar and pin head wire draws pin to press fit when hole filling is required, swages collar into pin grooves, and breaks pin flush with collar (Huck Mfg Co)

69. Huck blind rivet. Special gun pulls pin through sleeve (left) expanding latter to fill hole As pull continues (left center), sleeve is squeezed to form blind bulbed head Then, gun forces locking collar into conical space between recess in sleeve head and locking groove in pin (right center) Finally pin is tension broken, at breakneck groove, substantially flush with sleeve head.



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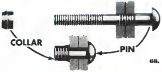

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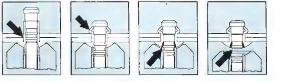

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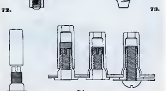

74.

70. Cherry self-plugging blind rivet, designed for applications requiring fastener with properties approximating those of solid rivet. Installation: (1) Gun head engages rivet stem, (2) shank expands as stem is pulled into rivet (3) stem is pulled entirely into rivet, (4) stem fractures at notch, and (5) stem is trimmed flush

71. Cherry hollow blind rivet (pull-through type) (1) Gun head engages rivet stem, (2) tulip head is formed when stem is pulled against rivet tail, and (3) shank expands through entire length as stem is pulled through rivet and ejected, rivet remaining as hollow unit. In company's regular type tulip head is formed, stem is then fractured, one part being ejected from gun, other from rivet.

72. Goodrich Rivnut, threaded internally, serves as blind rivet or nut plate. Device is screwed onto pull up stud of special heading tool, inserted in hole, and tool handle is closed to point of solid resistance to create bulge upset against underside of work. Available in various head styles, unit is fabricated with open end or closed end for sealed installations. When used as nut plate, keyed-head unit increases torque resistance. Splined type is designed for wood, plastics, etc.

73. Scrivet is rivet-screw combination, driven like screw and locking via top thread. Distance from top thread rise to head under surface is variable to suit requirements. Head (conventional styles) has Phillips recess (National Screw & Mfg. Co.)

74. Lok-Skru, for nut plate attachments, is inserted in hole for blind attachment and locked by drawing barrel over head shank with special tool. Available in various head styles, unit comes with open or closed barrel end. Similar unit, Lok-Rivet, is also made by Dill Mfg. Co.

75. Du Pont Explosive Rivet, available in various head styles, has shank cavity containing non-corrosive charge which detonates to expand shank and form upset when electrically heated riveting iron is applied to head.

ACKNOWLEDGMENT

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Service-Proving Certified This Integral Tank

By THEODORE P. HALL, *Development Engineer Consolidated Vultee Aircraft Corp*

Weighing but .13 lb. per gal., new Convair 240 fuel storage installation is dictated by long record of successful war-tested use in thousands of craft . . . Here are engineering experiences with this tank design and technical data on its latest application.

SUBSTANTIAL WEIGHT SAVING, also proved reliability, and trouble-free service—briefly, these are the principal reasons for using integral wing fuel tanks on an airplane. And these advantages translate into higher payloads and lower maintenance costs.

It was the first factor—weight saving—which in 1933, during preliminary design of the PBY Catalina flying boat, led Convair engineers to develop the first integral wing fuel tank. Since then the company has built approximately 2,800 planes equipped with tanks based on this design and is now installing them in its Convair 240 airliner.

Extremely long service life of these 2,800 planes—most of them Catalinas and many of them still flying—has conclusively proved the soundness of the tank design.

Using design-adapted structure, sealing strips of synthetic rubber, fuel-tight corners (partly structural), and fuel-tight stringer splices, integral tanks on Convair 240s weigh only .13 lb. per gal. of fuel.

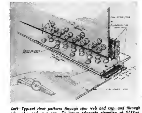
Cell-type fuel tanks for the same plane, plus plumbing, access doors, and lining, would weigh approximately .30 lb. per gal.

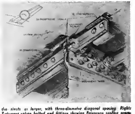
Separate fuel tanks, with their heavy gages, poor shape, supporting brackets, internal stiffeners, straps, interconnecting plumbing, and large access doors, would weigh at least .45 lb. per gal.

For the 240, with fuel capacity of 1,000 gal., Catalina-type tanks are 170 lb. lighter than cells, 320 lb. lighter than separate tanks. Expressed in percentage of payload, this saving ranges from 1.7 to 3.2%—representing, over a period of time, considerable extra profit for the operator.

Several other reasons prompted Convair engineers to use these tanks. They are inherently more reliable than cells, separate tanks, or internally-coated integral tanks. Unlike cells, they have no vulnerable plumbing, and because they are part of the structure, have heavier surfaces than separate tanks and are not subject to chafing or deterioration. They support relatively light concentrated loads, and location in center section outboard of engines precludes leakage hazard caused by local deflections.

Seams and joints are wide (6 in. at corners and $1\frac{1}{4}$ to $1\frac{1}{2}$ in. at seams). Some internally coated integral tanks, with only a thin film as a barrier to fuel passage, have leaked because of defects in the film resulting from omission, cracking, damage during servicing, or bond failure. Also, these leaks have been extremely difficult to locate,



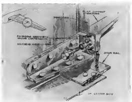


Left: Typical rivet patterns through spar web and cap and through wing skin and spar cap. To insure adequate clamping of 1/32-in. Fairprene sheet in Catalina-type tanks, Convair engineers use 3/16-in. dia. rivets or larger, with three-diameter diagonal spacing. Right: Z-stringer splice bolted and fittings showing Fairprene sealing grommets used in Convair 240 tanks. Note that bolts are double sealed.

since fuel traveled some distance before appearing at the tank surface.

Catalina type tanks require almost no maintenance. Once checked at the factory, seams and corners and spar and bulkhead rivets are practically trouble-free for life of the plane. Maintenance, if any, is confined to occasional replacement of a stained rivet at time of major overhaul The stain is invariably slight, and with proper rivet replacement, does not recur And it is a simple matter to repair those which have suffered minor damage in air or ground operations

Other advantages of these installations are complete utilization of space, resulting in maximum fuel capacity, cleanliness and ready access for inspection, and lower cost than separate tanks



Method of attaching flap support fitting to center section rib chord member fitting at rear spar, showing seals which permit easy bolt removal Fittings attached with bolts require special sealing provisions—consisting of countersunk of fitting face into which circular cross-section Fairprene gasket is inserted

Engineers on the original Catalina project concluded that they could design and build practical integral wing tanks for the plane, saving approximately 600 lb in weight. Basic idea of synthetic rubber sealing in tank seams was adopted, and various sealing materials and rivet spacings were tested for leakage and effect on structural strength. Problem of fuel-tight corners was solved by using welded steel in conjunction with void fillers.

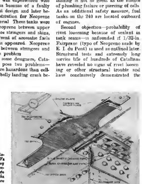
Some trouble was experienced with these early tanks because of a faulty sump attachment design and later because of a substitution for Neoprene as a sealing material These tanks were built without Neoprene between upper and lower surface stringers and skins, and with the advent of aromatic fuels some rivet stains appeared Neoprene strips installed between stringers and skins solved the problem

According to some designers, Catalina-type tanks pose two problems—they may be more hazardous than cell-type tanks in a belly landing crash because there is more chance of structure rupture than cell rupture, and use of sealing material in tank seams may lead to rivet loosening or other structural impairment

First objection is questionable—even for planes having concentrated landing gear fittings tied directly to tank structure But in planes like the Convair 240, with its landing gear structure isolated from its tanks, possibility of serious tank failure in belly landing is not so great as the chance of plumbing failure or piercing of cells As an additional safety measure, fuel tanks on the 240 are located outboard of engines.

Second objection—probability of rivet loosening because of sealant in tank seams—is unfounded if 1/32-in Fairprene (type of Neoprene made by E I du Pont) is used as outlined later Structural tests and extremely long service life of hundreds of Catalinas have revealed no signs of rivet loosening or other structural trouble and have conclusively demonstrated the soundness and efficiency of this integral fuel tank system.

Another example of the tank's efficiency is exemplified in the 18 converted bombers used to fly trans-Pacific routes of Consairway—wartime line operated by Convair for the ATC. These bombers, forerunners of the B-24 Liberator, were equipped with two 1,550-gal. integral fuel tanks. They flew 300,000,000 passenger-miles and 100,000,000 ton-miles, for a total of nearly 150,000 hr. When the airline was deactivated (Dec. '45), utilization had risen to a full 15 hr. per day per plane. Once placed in service, the transports developed no fuel tank trouble of any consequence Seven of these planes each flew more than 11,000 hr



Skin splice at inboard end of 240's fuel tank, depicting fuel-tight rivet spacing. Splice plate fingers complete the stringer splice where dagger fittings are installed.

Experiences With Design

Occasionally, Convair has experimented with, or departed from, its service-proved practice of building integral fuel tanks—and always with unsatisfactory results The C-87, transport version of the B-24, is an example. The B 24 originally had Catalina-type integral fuel tanks, but most of the design features were omitted when the wing was redesigned to accommodate self-sealing fuel cells that war experience had made mandatory for combat planes

Later in the war when C-87s were built to the basic B-24 design, the bullet-proof tanks were eliminated and attempts were made to restore fuel-tight integrity Result—since most of design features for Catalina-type tanks had been dropped—was unsatisfactory. This has caused some criticism of all integral tanks

Earlier in the war, while building a four-engine flying boat with fuel capacity of 4,400 gal., our engineers departed from Catalina-type tank technique with unsatisfactory results. They tried using a plastic sealing compound back of fuel-tight corners, thus proving unsatisfactory as a sealant, and requiring extensive rework to correct. Trouble here, as with the C-87s, was because of one simple fact—the engineers, in an effort to "improve" construction, had strayed far afield from proved Catalina practice.

In contrast, the company built a Navy transport, near the end of the war, with very successful integral tanks, primarily because the engineers followed Catalina practice to the letter Then used basic B-24 parts for the wing, but reviewed the entire design and followed Catalina type tank design requirements meticulously during both design and construction The four transports assigned to the Marines were flown more than 4,000 hr without having to go into a single tank.

Similarly, in 1939, the company constructed a 46,000-lb two engine flying boat with a 55 ft. wing center-section which was entirely integral tank, and results were excellent

Results have been excellent, too, on Model 110, experimental forerunner of the 240 Design and construction of the wing tanks followed Catalina practice closely, and a rigorous flight test program again proved the soundness of the tank design

During production on the 240, four men can air-test (3½ psi), inspect, and make corrections on the tank in two days. Percentage of rivet corrections during air test is considerably smaller than when these tanks were originally constructed

Success in building leak-proof integral tanks during the past 13 yr. has convinced our engineers that three important requirements must be met—basic design must be correct, proper materials must be used, and fine craftsmanship must be applied And logically, fuel-tight integrity is a parallel consideration with flight structural requirements of the wing.

Tank's Vital Details

Six major items require exacting attention in the design and production of these tanks—(1) Proper materials, (2) skin seams, (3) fitting attachment, (4) attachment of reinforcing plates and stiffeners, (5) carry-through of structural members, and (6) fuel-tight corners.

Sheet material—first item—must be sufficiently heavy to clamp the seam-sealing material between rivets Thinnest practical gage is .051, with .064 preferred as a minimum. All sheet material should be in the ST condition to insure clamping. Recommended seam-sealant is 1/32-in Fairprene 5570, which swells on contact with gasoline, tightening the seal even more

Closeup of 240's inboard fuel-tight bulkhead depicting corner installation and dagger fittings for carry-through of Z-stringers

Skin seams and lap joints should be as wide as practicable, and two staggered rivet lines are advisable Satisfactory rivet spacing, taken diagonally between rows, is 3 to 3½ diameters To insure adequate clamping of the Fairprene sheet, our engineers recommend a minimum rivet dia. of 3/16 in, and they use flathead rivets on tank interior, and machine, rather than dimple, countersink rivets Entire countersunk head should be contained in the outside skin to avoid head-bottoming and voids

Attachment of fittings to the tank structure is easily accomplished Fittings which are riveted to spar or bulkhead faces require no special treatment other than use of 1/32-in. Fairprene sheet between the fitting and the face Fittings attached with bolts require special sealing provisions at bolt shanks. This consists of a countersink at fitting face into which a circular cross-section Fairprene gasket is inserted As the bolt is tightened, the gasket is compressed against bolt shank

Attachment of reinforcing plates and stringers differs from normal practice only in that 1/32-in Fairprene sheet is installed at the faying surfaces. Fairprene is also installed under stiffeners and reinforcing plates on external surfaces of spars and bulkheads

Correct carry-through of structural members, such as upper and lower surface stringers across fuel-tight bulkheads, is also a very important problem Convair engineers have two methods of solving this problem—by using bolted end fittings butting against the bulkhead, or by using dagger fittings (straps with centrally located flanges) In the second method, dagger straps are passed through slots in the bulkhead and dagger flanges are riveted to bulkhead, Fairprene gaskets being used for sealing

Fuel-Tight Corners

Fuel-tight corners are most important and most difficult to attain Chief difficulty is because structure against which corners attach consists of hand-assembled parts lacking the accuracy of machined parts Hence, in designing corners, allowance is made for these manufacturing variations. Surfaces to which corners attach are built up flush, using fillers where necessary Definite voids are intentionally permitted, approximately ⅛ by ⅛ in., at edges of spar caps and bulkhead chord members. Corners are drophammered from 24SO .091 sheet heat treated to ST condition before installation Corners are surfaced with Fairprene sheet before assembly, and voids prepacked with non-contractive void sealer (Fairprene ground and mixed with liquid Thiokol) After riveting corners in place, voids are shot with sealer and openings closed with ½-in.-long aluminum plugs

During development of Catalina-type tanks through the years, wing structure has been simplified in the tank region to get rid of as many seams and voids as possible Original PBY tanks, for example, employed angle sections back-to-back for spar caps, whereas present spar caps are single extrusions Similarly, skin seams have been eliminated by using larger skins

Aside from variations such as these, service proved practice is followed in building integral tanks for the new 240

How New Douglas Skystreak Will Probe the Transonic

Flying fighter-type lab—embodying combined design proposals of Douglas, BuAer, and NACA—is implemented with 500 lb. of special instrumentation for high speed air load measurements at 400 craft-locations.

AT TIME OF THIS WRITING, Douglas' D-558 Navy Skystreak was being groomed for its grim and determined assault on the aerodynamic unknown—the transonic realm encompassing Mach .85 to 1.3.

If the craft's flight program is successfully achieved, phenomena will be revealed of extreme interest to structural engineers, aerodynamacists, and transonic wind-tunnel investigators.

One researcher in this last mentioned field has admitted that wind tunnel investigation has been brought up short before the transonic hurdle—that reasonably acurate readings and effects are obtained for Mach values up to about .85 and above 1.3, but for the range between these limits, results are somewhat inconclusive. It is felt that information to be gained via craft such as the D-558—if they are able to edge through the transition region and come out again with reliable readings on forces encountered—will provide valuable reference points from which calibration of transonic wind tunnels can be completed.

Basically, the Skystreak—despite its apparently conventional configuration—is a trial-and-error research tool. It is a "theoretical" design, and in its early projection Douglas, BuAer, and NACA found easy agreement in the idea of building the plane for its specific purpose.

However, when it came to actually welding together design proposals of these three engineering-group participants, understandable variations in viewpoint appeared without positive supporting evidence of forces that might or might not be encountered at various speeds.

It is to the credit of the plane's design and consulting engineers that they were able to surrender individual convictions in some instances and work together harmoniously in producing a plane that, in effect, is a theoretical compromise.

At this stage, project engineers feel that it would be unfair to give reasons for the Skystreak's structural stress design and aerodynamic shape in view of tangents of opinion embraced by the craft's makeup.

Power unit of the Skystreak is a General Electric TG-180 turbojet engine burning fuel similar to kerosene. Exact power is not revealed.

The craft takes off and lands under its own power—no mother ship being required. Takeoff and landing speeds will approximate that of present day fighters.

Gross weight with normal fuel load (230 gal.) is 9,750 lb. Wing loading at takeoff is 65 lb./sq. ft., for landing 50 lb./sq. ft.—approximately the same as wing loading for the Douglas A-26 bomber.

Wing span is 25 ft., craft length 35 ft., and height 12 ft.

Material for wing and control surfaces is 75S high strength aluminum alloy, and fuselage shell is lightweight magnesium alloy. Because of space limitations, tungsten alloy is required to balance ailerons. Strength of the craft is approximately 60% greater than current fighter design requirements.

This view of Skystreak shows separation of component sections: (1) Nose, containing intake duct and separable cockpit to facilitate emergency escape, (2) center section, mounting wing, engine, and instrument compartment; and (3) tail portion, carrying exhaust cone and empennage control surfaces.

Special wheels for landing gear are Bendix-built. Goodrich Nylon tires are inflated to 230 psi. and are especially thin to permit wheel retraction into the thin wing.

Pilot's cockpit—jettisonable—is provided with pressurization, insulation, and refrigeration and heating facilities. Fuselage is fitted with speed brakes for glide and dive control. And special instruments weighing about 500 lb. will automatically record air loads imposed by measuring pressures at 400 locations.

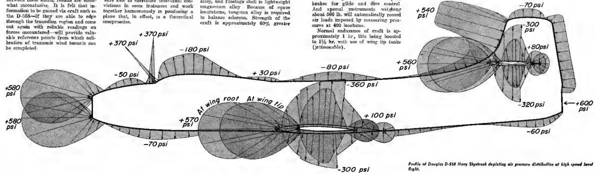
Normal endurance of craft is approximately 1 hr., this being boosted to 1½ hr. with use of wing tip tanks (jettisonable).

Accompanying profile pressure sketch of the Skystreak gives indication of the care used in the design development, and shows an unusually clean balancing of calculated pressure forces in high speed level flight. Although Douglas engineers are not permitted to disclose anticipated effects at specific speed figures, it is safe to assume that forces indicated are for a speed somewhat below Mach .9. And it may be observed that the configuration of the craft displays the intent of giving the pilot the smoothest possible ride in what is expected to be a very rough journey.

Chief Engineer of Douglas at El Segundo—Edward H. Heinemann—declares that the design should give development of shock waves and airflow separation in orderly sequence in areas of: (1) Wing roots and wings, (2) tail surface intersections, (3) pilot's bubble canopy, and (4) fuselage. It is conceded, however, that design to obtain this separation sequence was based upon theoretical analysis, with no supporting data. And not until the craft is safety returned from transonic flight, and the story of its recording instruments checked against the pilot's verbal report, will the engineers have confirmation or denial of their theoretical reasoning.

From the accompanying photographs it is evident that Douglas engineers have followed conventional structural assembly to a great degree, and fundamentally have simply built added strength into components which theoretically should have to bear the brunt of intense buffeting and sharp load fluctuations as the craft approaches and goes beyond Mach .9.

Discussion with Douglas engineering



Profile of Douglas D-558 Navy Skystreak depicting air pressure distribution at high speed level flight.

AVIATION, May, 1947

personnel disclosed that two particularly troublesome problems were temperature control of cockpit and various equipment items, and control of critical speeds of the craft's components

Problem of temperature control is attributed to adiabatic temperature rise that will heat all parts of the craft as it flys at constant altitude for an appreciable period. As an example of the magnitude of this problem, it is stated that an airplane flying at 600 mph will be heated, after approximately 15 min. of steady flight, to about 64 deg. above atmospheric temperature; at 800 mph it will be approximately 114 deg.; and at 1,000 mph., about 200 deg.

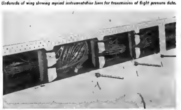
Since the Skystreak is intended to survey the transonic range from sea level to altitudes approaching 50,000 ft., it was necessary to design for a standard hot day (100 deg. F.) at sea level. And since human temperature endurance limit with 50% relative humidity is 100 deg., most hydraulic equipment was designed for only 140 deg., and electrical equipment for only 165 deg.

Also, since strength of aluminum alloy structures drops very rapidly at temperatures above 200 deg., it was necessary to afford unusual provisions to protect against exceeding such limit—i.e., a refrigeration system to cool ventilation air and pilot's compartment, and used in turn to cool instrumentation compartment, special ventilation around engine to cool accessories; insulation of tail pipe and high temperature portions of craft; and coating inside of fuselage structure with heat reflecting paint to prevent absorption of engine heat. Despite these precautions, under some conditions design-temperature limits of equipment probably will be exceeded, hence temperature values will require very careful observation during flight.

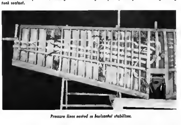
Extreme caution has been exercised in controlling pressure distribution on all parts of the plane—in order that local speeds will be kept as low as possible so that shock waves and drag rise may be delayed to highest possible speed. Much wind tunnel work was necessary to raise the critical speed of fuselage, engine air duct, cockpit enclosure, wing-fuselage fillet, and other installations, in order to raise critical speed of each item to the maximum practicable degree. In addition to this, it was important to control relationship of the various critical speeds to avoid catastrophic conditions when an item becomes critical. Thus, if tail surfaces become critical before wing, control of the craft will be lost. To prevent this, tail surfaces are thinner, and thus have a considerably higher critical speed than the wing.

Upon successful completion of the research program with the Skystreak, much of the haze enveloping transonic phenomena should be lifted—pointing the way to more efficient design of future combat craft.

Underside of wing showing myriad instrumentation lines for transmission of flight pressure data.



Tube fittings presented problem in this concentration of instrument lines in thin wing. Lines have additional protective coating of Stoner-Mudge compound, usually used in integral wing tank sealant.



Pressure lines nested in horizontal stabilizer.

Pre-Test Model of Tunnel Saves Research Time and Money

By R. C. MOLLOY, H. H. HOADLEY, and D. H. BRENDAL,
United Aircraft Corp.

How United Aircraft used 1/12th-size replica to develop improved and versatile wind tunnel with savings of thousands of dollars.

MATERIAL SAVINGS in cost—and almost-as-important time—have been achieved in United Aircraft's versatile wind tunnel laboratory by first building and thoroughly testing a 1/12-scale model.

Final result is a unique and versatile facility capable of testing full-scale power plant installations at 200-mph. airspeeds, as well as scale models of aircraft and propellers at airspeeds over 600 mph. The wind tunnel can test installations with engines up to 5,000 hp. equipped with propellers as large as 17 ft. dia.; it is the largest privately-owned wind tunnel in operation, the largest closed return tunnel built of concrete; and the first designed to handle both aerodynamic research and power plant testing.

Important elements of the completed laboratory are:

1. An 18-ft. 200-mph tunnel; alternate 8-ft. 600-mph. test section.
2. Outdoor engine test stand used in conjunction with tunnel for ground testing of power plant.
3. Propeller test unit for research on propellers at high speeds in 6 ft. throat.
4. Pilot wind tunnel for tests on relatively small models at 100 mph.
5. Equipment to provide two independent electrical variable frequency supplies with a combined maximum power output of 750 hp.
6. Extensive shop facilities for woodworking, metal working, and machining.

Versatility of the facility was a prime requirement from the very inception because of United Aircraft's diversity of products—aircraft, helicopters, aircraft power plants, and propellers. A high use factor was also an important consideration, for a wind tunnel must be judged by its results, not by its size, cost, and potentialities.

Analysis indicated that a dual test section tunnel would be considerably cheaper than two independent tunnels, in spite of the added complexity. Acceptance of this proposal meant that the aerodynamics of the tunnel circuit would have to be satisfactory for each test section, and that the compromise which would necessarily follow would not have a major effect on the performance of either section. The fan section would have to be designed for both configurations.

Table Comparing Performances of Model and Full-Scale Tunnel

	MODEL TUNNEL		FULL-SCALE TUNNEL			
			Rated Power		Overload To 9,000 Hp.	
	18 In.	8 In.	18 Ft.	8 Ft.	18 Ft.	8 Ft.
Maximum velocity (mph.)	205	545	204	586	224	655
Mach number	0.26	0.72	0.26	0.79	0.28	0.89
Power input to fan (hp.)	45.5	45.5	6,550	6,550	8,580	8,580
Energy ratio	2.24	8.03	2.15	7.25	2.15	7.25
Fan rpm	5,650	5,670	500	500	500	500

Aerodynamics of the tunnel circuit showed that to provide an expanding passage or diffuser from the 8-ft. test section to the full diameter of the tunnel downstream from the 18-ft. section, two interchangeable sections would have to be provided downstream—one the diffuser for the 8-ft. section, the other a tube of nearly constant cross section to join the 18-ft. section with the fixed portion of the tunnel circuit. A fundamental requirement was that the change from one section to the other could be made in one day (actual experience has proved the change can be made in 5 hr.)

To check the aerodynamic characteristics of the proposed tunnel, the 1/12-scale model was tested at full design speeds. The model was large enough so that the aerodynamics of the fan and air exchanger could be closely approximated as well as the characteristics of the diffuser, settling chamber, test sections, etc. These tests, covering approximately six months, proved invaluable, not only in guiding the design but in saving thousands of dollars, since the tunnel as originally conceived would not have proved particularly satisfactory. Accordingly, the authors of this article heartily recommend that a scale model be constructed, if at all possible, whenever a tunnel project represents a major investment—as most such tunnels do.

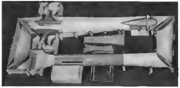
In testing the model tunnel, three different fan blade designs were tried, moreover, three diffusers for the 8-ft. section were investigated, as were three bellmouths. And a large number of modifications were made on the air exchanger to increase its efficiency. The model was particularly helpful in determining, for instance, what effect the fan section, and the diffuser after it, had on the air exchanger, and likewise the effect of the air exchanger on the flow in the settling chamber and test sections.

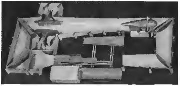
Final configuration of the 8-ft. insert was determined by tests on the model. From experience gained else-

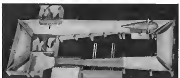
where, it was decided to limit the diffuser angle following the high speed test section to 7 deg. and, if possible, to reduce this still farther. The first model diffuser had an angle of 6.67 deg., and the test section and diffuser were circular in section.

Tuft studies showed flow separation very close to the test section. This condition was unexpected, since the diffuser angle was so low. It was considered quite possible that the separation was due to the severe, adverse pressure gradient resulting from the sudden change in direction at the entrance to the diffuser, so it was decided to introduce a transition flare between the end of the test section and the start of the straight diffuser.

A second design tested had a 10-in. long flare (10 ft. full-scale). At the same time, the cross sections of both test section and diffuser were changed from circular to octagonal for operational reasons. Only minor separation was observed in this diffuser, but the energy ratio of the tunnel was approximately the same as it had been with the circular diffuser which separated severely. This seemingly contradictory result was undoubtedly due to the addition of the longer high speed section inherent in the flare design.







Model shows how United Aircraft designed added versatility into its wind tunnel. Top: 18-ft. configuration for testing full scale power plants and propellers up to 200 mph. Note interchangeable 8-ft. test section in storage area inside tunnel circuit. Center: 18-ft. section moved out and 8-ft. section being moved in. Above: 8-ft. section—completing tunnel for tests up to 600 mph—in place.

A third and final diffuser reduced flare length to 4 in., and this proved satisfactory in that only slight separation of flow took place downstream, and design energy ratio was obtained.

Originally a very long nozzle (19 in.) was designed for the 8-in. test section to insure a uniform velocity distribution at the front of the test section. It was thought quite possible that tunnel losses could be reduced by shortening the nozzle, without having any detrimental effects on velocity distribution. Therefore, two abbreviated nozzles (2 in. and 4 in. shorter) were also tested.

Decreasing length of the first nozzle by 2 in. resulted in a 6.8% increase in velocity at rated power; and the additional 2-in. decrease resulted in an additional 2.9% rated power velocity increase. This was accomplished without measurably affecting velocity distribution across the test section. It is probable that the increase in tunnel energy ratio resulting from decreasing nozzle length is due not only to decreased frictional losses through the nozzle, but also to a higher diffuser efficiency resulting from improved boundary layer control conditions at the diffuser entrance.

Velocity distributions were measured in the high speed test sections of the model for various configurations, and the variation in velocity across the test section in every case was considerably less than 1%, excluding boundary layer at the walls. Later this was found to be the case with the full scale tunnel.

Performance of both model and full scale tunnel are summarized in the table accompanying this article, showing 1/12-scale model results, measured performance of the full scale tunnel, and calculated performance of the full scale tunnel using an overload rating of 9,000 hp. Model and full scale data are not quite identical, since the units differed somewhat in fan design. Operating the 8-ft. tunnel at 9,000 hp. would allow tests to be conducted well into the range where severe compressibility effects are encountered. A recent investigation indicates the feasibility of running at 9,000 hp.

Model tests with different fan designs revealed that efficiency of the air exchanger was critically dependent on the radial distribution of pressure rise across the fan. This was due merely to the fact that a high velocity distribution at the tunnel wall considerably improved effectiveness of the diffuser following the fan. Since the

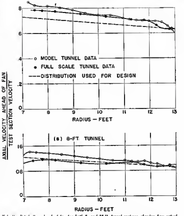
This finished product was built at a saving of thousands of dollars through careful studies of 1/12-scale model before freezing of final design. Authors recommend this method for getting better research facilities for less money.

air exchanger removes air from the tunnel walls at the end of this diffuser, its efficiency must be high for satisfactory air exchanger operation. The full scale fan design was thus modified to produce an increasing pressure rise as the blade tip is approached.

The scale model proved invaluable in another important final-design concept, for it brought about a decision to install both a resistance plate and a honeycomb in the full scale unit. This decision was reached for two reasons: First, velocity distribution in the 18-ft. test section as measured in the model tunnel for the optimum air exchanger configuration was still not as good as desired; second, there was an unsymmetrical, non-axial flow condition in the airstream which became apparent in the nozzle and carried on into the test section. This non-axial and rather turbulent airflow was confined to the layers adjacent to the vertical walls of the tunnel. This latter flow condition could not be traced entirely to the exchanger, since it was present—to a lesser degree—with the exchanger valves closed. It was also present in the nozzle of the 8-in. test section but appeared to be completely damped out before reaching the high-speed test section itself.

Model tests of various screen configurations indicated considerable improvement on the above flow conditions. A resistance with a pressure loss coefficient of 1.2 was selected for the full scale tunnel. The type of resistance selected was a perforated plate, because it was felt the accumulation of engine oil and dirt on such a plate would not result in such large changes in resistance and would be easier to clean than the usual wire screen. The perforated plate in the large tunnel was mounted on the corner vanes, which offered a convenient means of support. Further improvement in the velocity distribution in the test section was achieved by removing the plate on the two sides to increase the velocity at the vertical walls of the test section where velocity had previously been low.

On the basis of United Aircraft's experience with the scale-model tunnel, it is felt that all-important research facilities not only can be obtained with vast financial savings, but that these facilities can be made more efficient with great savings in time as well.



Velocity distribution ahead of fan for both 8- and 18-ft. tunnel sections, showing how actual conditions correlate with predictions made by scale-model studies.

Three large burlap-covered Calresin Plastiform-preserved plaster casts (foreground) in storage yard of Douglas El Segundo plant. Outmoded is old method (background) of leaving forms exposed to elements.

Rock-Like Plastic Preserves Valuable Aircraft Molds

Material made by Calresin Corp. provides comparatively easy and inexpensive means of treating production casts so as to permit safe all-weather outdoor storage.

SUGGESTING a technique that may be of considerable value throughout the aircraft industry, a low-cost method of providing apparently permanent means of preserving valuable plaster-cast molds is now being used by Douglas Aircraft Co.

In common with other aircraft manufacturers during the war years, the company accumulated an ever-increasing stockpile of plaster molds of aircraft parts—critical parts which would be highly uneconomical to reproduce from blueprints.

Shortage of labor and materials has precluded building of storage sheds to protect these exacting forms from the elements against the day of possible re-orders. Until plywood became almost impossible to obtain, Douglas and other manufacturers resorted to crating plaster casts for out-of-door storage. At best, this latter course was costly in man-hours and in its failure to thoroughly protect castings against intrusion of moisture.

To Roy Dudley, of the company's plastics department, goes credit for conceiving the idea of coating the plaster casts to protect them against the elements. His experience with Plastiform, a ceramic and thermoplastic product developed by Calresin Corp., Culver City, Cal., suggested use of the material as an easily applied durable coating for the casts.

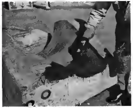
Calresin has a comprehensive strength of 10,000 psi; displays no shrinkage, expansion, or warpage; is resistant to acids and alkalies, and repellant to water, and oil; and in molten state can be applied with a paint brush.

Dudley's estimates of the values of the cast-protective coating were supported by laboratory tests in which coated casts were subjected to heat, cold, steam, salt, acid, and water immersion. As a result, open storage of Plastiform-coated casts has become standard Douglas practice.

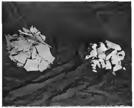
As delivered to the consumer, the West Coast plastic has the appearance of grey rock-like fragments. The material is reduced to a liquid state in an electric double-boiler capable of maintaining a temperature of 300 deg. F. Plastiform's melting temperature is 240 deg. F.

The molten material then may be brushed onto the surface of the plaster cast, which has first been treated with

Here a workman applies a 10% viscosity oil coating to mold prior to brushing on Plastiform. Application of oil prevents bonding of plastic to form thus enabling easy removal when desired.



Plastiform may be applied with ordinary brush, like paint. And one coat is stated to be sufficient. Particular cast shown here will be protected at a cost of about \$2. Thickness of coating is about 1/16 in.



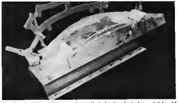
At left, resembling gray slate, is plastic after having been peeled or chipped from a cast; white at right is same material as delivered by maker. A further economical feature of Plastiform is that it may be used over and over.

a light coating of either 10% viscosity lubricating oil or ordinary cup grease, the latter being preferred by Douglas as a treatment for rough surfaces. For the protection of exceptionally large surfaces, such as casts of wing tips, Douglas wraps the grease-coated casting in burlap, then applies the Plastiform.

Hardening of the plastic is almost immediate, and at any later time it may be removed easily after a preliminary chipping away of a segment of the shell. In some instances where Plastiform is applied directly to a greased surface, it has been found that after chipping off a piece of the coating, a spurt from an airhose will free the remainder of the plastic shell, which retains an indelible female impression of the male design it protected. This Plastiform mold could be used for reproduction of more plaster impressions.

Experience at Douglas indicates that plaster casts given this new treatment can be used with little or no "brushing up", no matter how long they have been left in open air storage. Previously it was not uncommon to have to spend up to 8 hr. in sanding a plaster cast back to exact shape after it had become swollen and distorted in semi-protected storage.

An indication of the economy possible through use of this plastic treatment is seen in the fact that Douglas only finds it necessary to coat the matrix surfaces of plaster casts intended for outdoor storage; sides and under surfaces of the heavy plaster blocks may be left unprotected.



Versatility of plastic material is seen here in North American Aviation's use of it in solid form as a rout jig for dural and other metals. Part to be drilled is laid on form, and clamps hold work in position.

SIMPLIFYING PERSONAL PLANE DESIGN

PART III

By RALPH H. UPSON, Consulting Engineer

Presenting details of performance computations, Engineer Upson considers aspects of maximum speed, cruising speed, and climb and ceiling . . . Last installment of this practical analysis.

It seems to be commonly assumed that the main purpose of performance computation, in advance of detail design or construction, is merely to predict results. Thus, an engineer may point with pride to attainment of a speed within one or two miles per hour of his advance prediction; and some people may make much of his feat. But is he really entitled to credit merely for correct prediction? If so, I could enter a mile race against Dodds and Haag, and make good my predicted time of, let us say, six minutes flat. But predicted or not, this result is inconsequential. And it is the same with airplane design—winning, not just prediction, is what counts; and this can be insured only by the best possible combination of engineering elements for safely getting desired or maximum performance at minimum cost.

As previously indicated in this series, for a basic approach to this objective, it is hard to beat a good old fashioned plot of power-required and power-available vs. speed, especially with the quick and easy formulas brought out in Part II (AVIATION, Aug '46). Use of these formulas requires fundamental data from experience, wind-tunnel test, or reasonable assumption covering:

1. Maximum sea-level efficiency η_{m}.
2. Speed v_m at which this efficiency occurs.
3. Speed v_p (with fixed pitch) at which rated hp_r is developed,
4. Rated rpm. ($=1{,}000\ N_r$),
5. Total airplane weight W,
6. Drag area f,
7. Induced factor e, and
8. Relative air density σ.

(See example plotted in Fig. 4.)

From the very nature of the formulas and the curves plotted from them, the general effect of varying the different parameters should be fairly obvious. A good preliminary idea can thus be obtained of where to look for improved results, even without precise knowledge of their numerical magnitude. Still, numerical results will be useful to any extent that they can readily be had.

Suppose, for example, that superior performance in general is desired. Anything that generally widens the gap vertically between the power required and available curves in Fig. 4 will improve top speed by moving the right hand intersection further to the right; improve climb by increasing effective margin of power-available over power-needed; and improve ceiling by extending to a higher altitude, conditions which make the two curves tangent. Offhand, it would seem as if there ought to be some combination of factors that would express this general relation between the two curves in a manner that would be useful in computing all three of these major performance objectives.

There is such a combination factor, the major performance parameter A_1 (Ref. 1, AVIATION, June '46). To this will now be added another fundamental concept—the fictitious maximum speed v_m' that would be obtained at sea level ($\sigma = 1$), without the second or induced term of the power-required equation, by using the full rated power hp_r at maximum efficiency η_m (AVIATION, Aug. '46 Speed v_m for the rated rpm., at which this maximum efficiency occurs was also explained in that same article.) Both of these artificial, but simple and convenient, parameters are mathematically defined in our outline of symbols.

It may be noted that A_1 as here used is not exactly the same as Oswald's A (Ref. 7), being based on sea-level thp. at speed of maximum efficiency (assuming variable pitch propeller), whereas Oswald's is based on sea level thp. at maximum speed[2]. A similar distinction exists between v_m' and Warner's v'_m (Ref. 5, AVIATION, Aug. '46). Thus, these important basic parameters here represent strictly airplane characteristics, and are not in any way functions of the flight conditions or of the performance to be computed.

Maximum Speed

An exact solution for v_m in level flight at any altitude would, of course, be obtained by putting $thp_r = thp_a$ from Eqs. (13) and (14)' or (13) and (15) AVIATION, Aug. '46 and solving for v. Unfortunately direct algebraic solution in this case is impossible, but the situation readily lends itself to simplifying assumptions accurate enough for practical purposes.

First, it is assumed that maximum speed is of no interest at more than a moderate altitude of say 10,000 ft.—which would also take care of any supercharging likely to be used for personal aircraft. This assumption keeps the second or induced term of the power-required equation relatively small, hence easy to approximate.

Further, it is assumed that the propeller is either: (a) Constant rpm. with power available thp_a from Eq. (14), giving a maximum speed v_m, or (b) fixed pitch with rated power developed at v_p, where v_p is usually less than v_m from item (a).

Takeoff and climb are favored by making $v_p < v_m$; but then unless some over-revving is permissible, maximum speed must be made with a throttled engine which, as will be seen, puts its value about half way between v_p and v_m.

Returning to the case of a variable-pitch propeller at constant rpm. and at any given constant airplane speed, we see from the first form of Eq. (14) that in terms of the sea level thrust horsepower $\eta_1 hp_1$, the thp. at moderate altitudes is relatively insensitive to changes in the speed ratio v/v_{m}. By putting $v/v_m = 0.8$, the exponent of σ becomes 1.23, involving no error at $\sigma = 1.0$ (S.L.), and less than $\pm$ 0.3% in maximum speed for extreme values of $0.6 < v/v_m < 1.0$ at $\sigma = 0.738$ (10,000 ft.). By substitution of η_1 from Eq. (17), power available at maximum speed v_m then becomes:

$$thp_a = \sigma^{1.23}\,\eta_m hp_1\,[1 - (1 - v_m/v_{m1})^{3/2}] \qquad (3.1)$$

Power available from (3.1) can now be put equal to the power required in Eq. (13). By algebraic manipulation, the resultant equation can then be expressed as:

$$A_1/\sigma^{2.8} = 150y\,[1 - (1 - y/a)^{3/2} - y^3] \qquad (3.2)$$

where y and a represent groupings of factors as follows: $y = v_m/\sigma^{.08}\,v_m'$, $a = v_m/\sigma^{.08}\,v_m'$ (see list of symbols).

Thus the problem boils down to one unknown y, as an implicit function of two parameters, a and $A_1/\sigma^{2.8}$, in which the isolation of the latter makes for convenient tabulation and plotting (Fig. 4). Performance parameter A_1 will vary from about 10, for an unusually clean ship of low power loading and large span, to 20 at the other end of the scale. As $\sigma^{2.8}$ at 10,000 ft is 0.50, $A_1/\sigma^{2.8}$ may possibly run as high as 40. A simple empirical approximation of these curves in the specified range gives Eq. (24) for maximum speed with a variable-pitch propeller. Although this approximation is of the straight-line type, it follows a secant relationship to the original curves, instead of the more usual tangent line, thus greatly increasing its range of application.

The case of fixed-pitch utilizes the variable-pitch parameters as in the power-available formula of the preceding article (Aug '46). For present purposes, maximum speed can safely be assumed to occur in a region where the efficiency curves (for constant rpm.) are quite flat. Thus Eq. (15) shows that at a given altitude, full-throttle hp (and hence rpm.) with a fixed pitch propeller is proportional to $\sqrt{v/v_m}$ where in this case $v \approx v_m$. As moderate throttling reduces the speed approximately in proportion to rpm., the maximum permissible rpm. $(1000N_r)$ can be recovered only by reducing the speed v_m (by throttling) in proportion to $\sqrt{v_{p1}/v_m}$. Thus, with a further empirical factor $1/\sigma^{.03}$ the maximum speed v_{mp} is given by Eq. (25) for a fixed-pitch propeller.

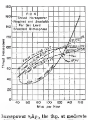
Although certain other secondary factors have been neglected, the formula is found to be close, but a little on the conservative side, for normal conditions of use. When the sea-level speed v_{p1} at which the fixed-pitch propeller develops its maximum permissible power and rpm., is equal to the maximum sea level speed v_m with variable-pitch propeller, it is then of course operating at full throttle. The second form of Eq. (25) shows the difference in behavior with altitude, in which case the top speed with a fixed-pitch propeller is almost equal to that with variable-pitch at any moderate altitude. Factor $\sigma^{.03}$ is the same in effect as given by Warner (Ref 5, Chap XVI)

Cruising Speed

In the absence of a rational standard, cruising speed can honestly be anything up to maximum that the manufacturer chooses to advertise. But what might be a rational standard?

It is claimed by various aerodynamicists that cruising speed should be defined as the speed of minimum drag or minimum fuel consumption, but this is about equivalent to claiming that Spring begins on Mar. 21st, even if a blizzard is raging at the moment.

By common consent, the practical meaning of cruising speed seems to be simply the speed at which you should normally fly a particular airplane to get the most good out of it. If you were interested exclusively in minimum drag (normally at a speed somewhat less than that of minimum operating cost), you would want a plane designed along quite different lines from any that seem to be available, or in demand, at the present time. Speed v_d of minimum drag is readily found by differentiating Eq. (2.2) (AVIATION, Aug '46) and corresponds to the value which makes the two terms equal, the solution for v_d being represented by Eq. (26). Thp., Eq. (27), is obtained by substituting this speed in Eq. (13), and corresponds to



Data For Figs. 4 and 5

POWER REQUIRED (thp_r in Fig. 4 and data common to all curves in Fig. 5). Airplane characteristics taken from Design C—3-place low wing craft, with fixed conventional gear—of "Designing Tomorrow's Personal Airplane," Table I, page 147, AVIATION, July '45. (For explanation see "Design Data," same article.)

Gross weight	$W = 2{,}075$ lb.
Wing span	$b = 35.3$ ft
Drag area	$f = 5.44$ sq. ft.
Induced (span-squared) factor	$e = 0.85$
Relative air density	$\sigma = 1.0$ (S. L.)

POWER AVAILABLE:

1. Common to all curves except thp_r. Rated brake hp. at S. L. $hp_1 = 122$, power-drop factor (P.D.F.) = 0.8. Drag area in slipstream, $f_1 = 2.94$. Wood propeller, 2 blades, Clark Y section (NACA TR 540) activity factor 80.
2. Variable-pitch (V.P.) curves for 5.45-ft dia. (full-speed direct-drive). Rated 2,750 rpm. ($N = 2.75$). Maximum efficiency $\eta_m = 0.775$. Speed of maximum efficiency, $v_m = 200$ mph.
3. Variable-pitch (V.P.) curves for 8-ft. dia. (geared down). Rated 1,500 rpm. ($N_r = 1.5$). Maximum efficiency, $\eta_m = .815$. Speed of maximum efficiency, $v_m = 150$ mph.
4. Fixed-pitch (F.P.) curves for 8-ft. dia. (geared down). Same basic characteristics as (3). Airplane speed setting, $v_{p1} = 120$ mph. Blade angle (at 0.75R), 24 deg. Small-dot extension beyond 120 mph. in this case is above rated rpm.

Note: Performance figures quoted in Part I of this series (July '46) were for a compromise fixed-pitch propeller.

[1] Rockefeller's $A\sigma = A_1/\sigma^{3/2}$ (Ref. 8) is the corresponding value at any given altitude, requiring division by a further factor $\sigma^{3/2}$.
[2] As corrected, $thp_a = \eta_1 hp_1\,\sigma^{\ldots}$

$A_e/\sigma^{2/3} = 63$ where A_e is equivalent to A_1 except computed from the actual thp developed at the speed and altitude in question. Actual L/D for this condition is given by Eq. (28).

Take as a numerical example, a plane[a] designed for an actual cruising speed of 120 mph., top speed 130.5 mph., and having minimum drag at a S L speed of 85.5 mph; where power developed is only about 40% of maximum available, as against 70% for 120 mph. It might be argued that the power actually provided is mainly dictated by takeoff and climb requirements, hence it doesn't otherwise have to be used. Quite true; but, seriously, who is going to be satisfied to use normally only 40% of total power, to make less than 2/3 of his possible speed? A similar situation exists with an automobile, maximum engine power being largely dictated by ability to accelerate and climb. But how many people do you find cruising across country at 30 mph.—a fair average for minimum fuel consumption, or much slower yet for minimum drag?

Practically speaking, the average pilot usually revs his engine the most he thinks it will take without being subjected to undue depreciation. But from this standpoint he is sadly lacking in real knowledge on at least three aspects. (1) How much depreciation is "undue"?; (2) how does rate of depreciation vary with power?; and (3) how does it vary with rpm. at a given power?

Coordination of items (1) and (2) has been attempted by the airlines where it is claimed that minimum operating cost per passenger (or ton) mile is attained with engines developing 55 to 60% of rated meto power; but this is with relatively high-speed planes running a large number of hours per year, and still makes no allowance for the economic value of speed as such. Prevailing practice with lightplanes is more on the order of 70 to 80% of rated power, with engine manufacturers trying to hold it down and plane manufacturers tending toward the upper figure.

The last item (3) is important, since if it can be shown that there is no particular advantage in merely reducing rpm. (providing it is below any critical stress or vibration point), the power reduction can be had merely by resort to altitude, with a substantial gain in speed and fuel economy on trips of reasonable length. In fact, the practice seems to be becoming more prevalent to base cruising speed on 7,000 ft. altitude—where a fixed-pitch propeller

[a] Type C, page 147 July '45 Aviation, author's series "Designing Tomorrow's Personal Plane"

THIS MONTH'S FORMULAS

(Performance with Unsupercharged Engines)

Top-Speed Level-Flight

Constant rpm (variable pitch).

$$(24)\quad v_m = \sigma^{.08} v_m' \left[1 - \frac{A_1/\sigma^{2/3} + 37.5}{375 - 170\,[v_{m1}/(\sigma^{.08}v_m') - 1]^{3/2}} \right]$$

$$= v_m' \left[1.08 - \frac{1.6A_1 + 36.8}{375 - 170\,(1.017 v_{m1}/v_m' - 1)^{3/2}} \right]$$

the last for $\sigma = 0.811$ (7,000 ft.)

Fixed Pitch:

$$(25)\quad v_{mp} = \frac{1}{\sigma^{.08}} \sqrt{v_{p1} v_m} \text{ for } v_{p1}/v_{m1} < \sigma^{.08} \quad \text{Interpolate for}$$

$$\text{or } \sigma^{.08} v_m \qquad \text{for } v_{p1}/v_{m1} = 1 \qquad \sigma^{.08} < v_{p1}/v_{m1} < 1.0$$

Speed for Least Drag and Flattest Glide (No Wind)

$$(26)\quad v_d = \sqrt[4]{\frac{220\,W}{\sigma b \sqrt{ef}}}$$

$$= \sqrt[4]{\frac{239\,W}{b f^{1/2}}} \text{ for } e = 0.85$$

$$= \sqrt[4]{\frac{295\,W}{b f^{1/2}}} \text{ for } \sigma = 0.811$$

Horsepower for Least Drag (Level Flight)

$$(27)\quad hp_d = \frac{1}{\eta_d} \sqrt[4]{\frac{.00355\,W^3 f^{1/2}}{\sigma e^{3/2} b^3}}$$

$$= \frac{.063}{\eta_d} \sqrt[4]{\frac{W^3 f^{1/2}}{\sigma b^3}} \text{ for } e = 0.85$$

$$= \frac{.07}{\eta_d} \sqrt[4]{\frac{W^3 f^{1/2}}{b^3}} \text{ for } \sigma = 0.811$$

Maximum L/D and Glide Distance/Height (No Wind)

$$(28)\quad (L/D)_{max} = 0.885\, b\sqrt{e/f}$$

$$= 0.816\, b/f^{1/2} \quad \text{for } e = 0.85$$

Speed of Best Climb (sea level)

Any propeller*:

$$(29)\quad v_{c1} = v_m' \left[.0335\,A_1 + 0.45\,(\eta_{01}/\eta_{.5})^{3/2} \right]$$

Best Climb (at v_c Sea Level)

Any propeller*:

$$(30)\quad C_1 = \frac{33{,}000\,\eta_{01}\,hp_1}{W} \quad (\eta_{.5}/\eta_{01} - .011\,A_1 - 135)$$

Ceiling (at $\sigma = .64\sigma_e$')

Constant rpm. (variable pitch):

$$(31)\quad \sigma_e = 0.129\,(v_{m1}/v_m')^{6.82}\sqrt{A_1} = \frac{0.31\quad\sqrt{A_1}}{3 - (1 - \eta_{.5}/\eta_{01})^{2/3}\ldots}$$

For fixed pitch ($PDF = 0.8$), use second form of (31)*.

Speed of Best Climb (Any Altitude)

Any propeller:*

$$(32)\quad v_c = v_{c1}\,\frac{1 - \sqrt{\sigma}}{1 - \sqrt{\sigma_e}} \quad (0.64 v_m' - v_{c1})$$

Best Climb (Any Altitude)

Any propeller*

$$(33)\quad C = C_1\,\frac{\sqrt{\sigma} - \sqrt{\sigma_e}}{1 - \sqrt{\sigma_e}}$$

* For fixed pitch: Use variable-pitch values v_m, v_m', $\eta_{.5}$, v_{c1}, and A_1, but instead of $\eta_{.5}/\eta_{01}$ use actual S.L. power ratio $thp_1/thp_{.5} = \eta_{.5}hp_1/\eta_{01}hp_{.5}$, where hp_1 = brake hp. developed at a S.L speed of $0.5v_m'$.

SYMBOLS

$A_1 = \dfrac{W^2 f^{1/3}}{eb^2 (\eta_{01}hp_1)^{4/3}} = \dfrac{52.8\,W^2}{eb^2 \eta_{01}hp_1 v_m'}$

$v_m' = 52.8 \left(\dfrac{\eta_{01}hp_1}{f} \right)^{1/3}$ (mph.)

W = gross weight (lb.).

f = profile-parasite drag area (sq.ft.)

e = Oswald span factor = 0.85 for preliminary estimates.

b = wing span (ft.).

hp_1 = sea-level bhp at maximum operating rpm

η_{01} = maximum propulsive efficiency at S L. when developing hp_1 (variable pitch)

v_{01} = speed at which η_{01} is developed

$\eta_{.5}$ = propulsive efficiency at speed $0.5v_m'$ (sea level)

hp_d = Bhp at minimum drag

v_d = speed of minimum drag

η_d = propulsive efficiency at speed v_d (throttled); can conservatively be estimated about 10% less than η_{01}

v_p = speed at which fixed-pitch propeller develops hp_1 (sea level)

v_m = maximum speed (variable pitch)

v_{m1} = same, at sea level.

v_{mp} = maximum speed (fixed pitch) (mph.)

σ = relative air density (compared to standard S L. density)

σ_e = σ at ultimate ceiling

C = climb (fpm.)

C_1 = C at sea level.

v_c = speed of best climb (mph.)

v_{c1} = v_c at sea level

References

Continued from Part II, page 75, Aug '46 AVIATION

7 *General Formulas and Charts for the Calculation of Airplane Performance*, by W. Bailey Oswald TR 408

8 *General Airplane Performance*, by W. C. Rockefeller, TR 654

9 *Airplane Climb Performance*, CAA Flight Engineering Report 3,

will absorb only 76% of its sea level power at equal speed, a variable-pitch propeller about 77%, and where the actual speeds at full throttle are on the order of 97 to 98% of the maximum attainable at sea level (Eqs. 25 and 26).

Still another way of looking at cruising speed is as a fundamental requirement set up in advance of design. According to this conception, fundamental question is not "Here is an air plane, how fast will it cruise?" but rather "Here is the speed at which we want to cruise, how can it best be attained?" Such speed may be selected in any rational manner, such as meeting competition of another manufacturer's product, customers' and dealers' demands, or as mere personal judgment of a qualified advisor. This method of picking cruising speed and other performance requirements in advance was employed in our "Designing Tomorrow's Personal Plane" series as by far the best way to judge the relative worth of different designs and possible improvements

Climb and Ceiling

Climb at any altitude and speed is of course a function of plane weight W and excess of thp available over what is required for level flight. Numerically, in the usual units of ft. per min., rate of climb is:

$$C = \frac{33{,}000}{W}\,(thp_a - thp_r) \qquad (3.3)$$

Conventional method of plotting power required and available has already been referred to and should be used as a final check of the finished design. Preliminary studies, however, will be much more rapidly and effectively handled by approximate formulas employing the same principle

Best climb is of course at sea level, and is tentatively confined to that condition. Climb C at any speed v, is determined from (3.3) by methods similar to the procedure already described for top speed, giving the following result

$$\frac{WC}{33{,}000\,\eta_{01}hp_1} =$$

$$1 - (1 - y/a)^{3/2} - y^3 - \frac{A_1}{15by} \qquad (3.4)$$

where in this case, at sea level,

$y = v/v_m'$ and $a = v_{01}/v_m'$

Empirical simplification then leads to Eq. (29) which, although most accurate for a variable-pitch propeller, is also within normal engineering accuracy for fixed-pitch (with corresponding difference in $\eta_{.5}$). Substitution of this speed in (3.4), with further simplification, finally gives the actual best climb expressed by Eq (30).

Although ceiling can physically be best defined as the altitude where climb drops to zero, a mathematical solution on this basis is unduly complicated. It can be shown, however, (Ref 8), that the effective performance parameter $A_e/\sigma^{2/3} = 75$ at the ceiling. A similar development to that for speed and climb results in the two forms of Eq (31), the second good for either a variable or fixed-pitch propeller

It is apparent that between sea level and ceiling, speed of best climb and climb itself will be intermediate between the corresponding values at these two levels. Ref. 9 shows that climb is almost a linear function of altitude, a relation that becomes still more accurate if $\sqrt{\sigma}$ is used instead of actual altitude. Speed of climb is subject to much less variation, and is assumed to vary in the same manner as climb. Formulas (32) and (33) are the direct results. Alternatively, the following simple graphical representation can be used: On $x = \sqrt{\sigma}$ as abscissa, plot v_c in a straight line from $0.64v_m'$ at $x = \sqrt{\sigma_e}$ (Eq. 31) to v_{c1} (Eq. 29) at $x = 1$; plot C in a straight line from 0 at $x = \sqrt{\sigma_e}$ to C_1 (Eq. 30) at $x = 1$. Almost as accurately, a linear scale of actual altitude may be substituted for $\sqrt{\sigma}$, as already indicated. At any desired altitude (or its corresponding $\sqrt{\sigma}$), values of v_c and C are simply read off (Fig. 5).

A Final Word

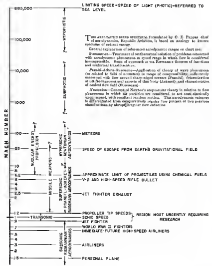
From a quick look at these formulas, their claim to simplicity may be called into question because they appear slightly more involved than certain elementary types. This apparent complication, however, is only because they are explicit functions of all the important *airplane* parameters, thus making for direct easy solution when these parameters are known. When they are not known, it is better to roughly estimate, or even to make a chance guess, than to use a formula which completely ignores them. Then, at least, there is some appreciation of the relative importance of these various factors in design. For example, instead of guessing at the actual propulsive efficiency for some particular condition of operation, it is easier, safer, and more instructive to assume the maximum efficiency, the speed at which it occurs, and how it varies with speed and altitude. Approximate formulas governing these variables are given here and in Part II (AVIATION, Aug '46), but still rougher approximations may be substituted at the discretion of the responsible engineer—and the basic formulas will still work.

In other words, so long as the increased number of variables can be neatly packaged, and used only to the extent needed, there seems no need for the aeronautical engineer to be in the position of the farmer who wrote the Department of Agriculture: "Please don't send me no more of your liter'ture. I already know how to do twice as well as I'm doin'."

Note: In Part I of this series (Aviation, June '46), exponent in Eq. 1 (page 59) should read .81. Also under symbols (page 59) definition for q should refer to Eq. 10 instead of Eq. 8. In Part II (Aug '46), expression for v_m in Fig. 2, page 72, is intended to mean .87 at C_{Dp} = .065. Symbol y in Fig. 3, page 73, is intended to be v; also upper full line curve and dash curve should be tangent to horizontal line 1.0 at x = 1.0. On page 74, expression "for σ = .811 (7,000 ft.)" in Eq. 13 applies only to second form of equation. In Eq. 14, symbols $\eta_0 hp_1$ should be inserted after first equal sign. In Eq. 15 equal sign after hp_1 is to be omitted. Eq. 17 is deemed closed by bracket at end. In line 2 of Eq. 20 expression "for diam. = 17/N_s" is deemed appended to end of line 1 of equation. In Eq. 21, term should appear $\overline{\eta_{01}}$. In col. 2 page 74, term hp_{a1} in Eq. (2.12) should be thp_{a1}, and in same column, second line from bottom σ should be $\sqrt{\sigma}$. In Eq. (2.12), page 74 expression $\sigma^{1/2}$ should be $\sqrt{\sigma^{1/2}}$. On page 75, under symbols fourth line from bottom, first word "chord" should read "tip chord."

SHEET NUMBER	D-39
CLASSIFICATION	*Measurements*
SUB CLASSIFICATION	*Mach Ranges*

SPEED SPECTRUM



This aeronautic speed spectrum, formulated by C. E. Pappas, chief of aerodynamics, Republic Aviation, is based on analogy to known spectrum of radiant energy.

General explanation of referenced aerodynamic ranges on chart are:

Riemannian—Treatment of mathematical solution of problems concerned with aerodynamic phenomena in speed range in which flow is considered incompressible. Basis of approach is via Riemann's theories of functions and conformal transformation.

Prandtl-Ackeret-Busemann—Application of theory of wave phenomena (as related to field of acoustics) in range of compressibility, collectively concerned with flow around sharp-edged corners (Prandtl), determination of lift from geometrical aspects of thin body (Ackeret) and characteristics of conical flow field (Busemann).

Newtonian—Concept of Newton's corpuscular theory in relation to flow phenomena in which air particles are considered to act semi-elastically upon impact, with resultant random motion. This aerodynamic category is differentiated from comparatively regular flow pattern of two previous classifications by abrupt irregular flow deflection.

WORLD LEADERSHIP...

Our Duty and Our Opportunity

Capitalism in Europe and the rest of the world is challenged by a real and formidable rival, communism. For capitalism to thrive a reasonable amount of prosperity is essential. Communism uses poverty to advance itself.

Except for the Western Hemisphere, most of the world came out of the war poor. Two years after V-E Day it is still poor. It needs dollars. It needs credit. It needs capital. It needs trade. It needs technical and managerial skills.

If we in America are to help the rest of the world back to its feet, starting it again on the road to peace and a free economy, we should try to supply those needs within the limits of our capacity.

We must not overtax our own strength. For the first requirement of a stable world is a strong United States. But we must accept leadership in international economic recovery—in our own self-interest.

What can the United States do to help men back to prosperity in a world economy which will allow them *freedom and incentive*? There are many things. But here are two of the most important:

1. The United States, through Congress, must determine the pattern and the total of the foreign loans or grants it can afford. We must answer three questions. How much will the new program cost? Can we afford it? Have we the technicians and managers to watch the loans, assuring their fruitful use?
2. We must demonstrate that we do not intend to raise our tariff walls to prohibitive heights when our debtors begin to repay us in goods and services, which is the only practical way they can pay us. Otherwise our loans will become losses.

If the United States is to meet even the minimum requirements of world rehabilitation, Congress eventually must authorize more advances than those to Greece and Turkey. The $400 million for those two countries will not do the over-all job of political and economic defense which we have begun. A minimum of $5 billion, if promptly and wisely applied in eight to ten countries, might suffice. BUT this $5 billion will be on top of approximately $16.8 billion which we have spent or earmarked during the past two years for use abroad, including our full share of the World Bank and Fund. We shall do a faster and more effective job if Congress will thus add up the foreseeable total of our international aid, and, even though the total looks imposingly large, commit us to it, with proper collateral safeguards from the debtor nations.

Congress need not try to foretell all contingencies, like last winter's weather in Britain, and it certainly should not create the impression that nations need only ask for billions to receive them. On the other hand, the war should have taught us the miserable consequences of "too little and too late." The President should have learned that he engenders skepticism by going to Congress with parts of a program, as he has done in the British, Grecian and Turkish loans. Within the limits of our capacity, we must make the decision now to see the whole job through—or throw in the sponge.

In the interest of the debtor nations—as well as in our own interest—the loan program should be hard-boiled. Rehabilitation loans must really rehabilitate. They must produce a state of economic health which will permit the World Bank and private capital to take over the task of financing world recovery—as perhaps can be done today in France and the Low Countries.

The loans, therefore, must be within the limits of our technical and managerial ability to implement them. Without technical help, Greece can not use its loan effectively—to rebuild railroads, clear ports, revive agriculture. Without skilled supervisors, Germany can not be made to pay its way. Money alone won't pull China from the brink of economic chaos.

Our lending calls for more than money. It calls for trained personnel to help the recipients utilize the loans effectively—geologists, construction and sanitary engineers, monetary experts, and management and agricultural specialists.

Loans are necessary but they are only a first step. A long-range program requires the opening of the half-closed doors of world trade—our own door, too.

We will have to get used to the idea that, when our debtors pay us, they must pay us largely in goods and services. Refusal to permit such repayments in the twenties helped start the world depression in the thirties—and the loss of our investments. *Imports do tend to raise living standards, and a two-way trade program need not require us to slash our present tariff rates.*

The complexion of our foreign trade has changed since the war. Our manufacturing capacity has increased and our raw-material self-sufficiency is tending to decline. For example, we probably shall have to continue importing copper and zinc and to increase our prewar dependence on imported lead. We may soon have to depend heavily on imported oil, and—gradually—on a growing volume of iron ore from abroad. Our normal dependence on imports for commodities like rubber, tin and silk will continue.

Our population has gone up 10 million in the last decade, and we now have a $176 billion national income, making room for more imports.

As a result of every nation's recent attempts to make itself secure and self-sufficient by slamming its trade door, a world-wide series of quotas and restrictions is blocking international trade. Even more, government buying and selling threaten to take commerce out of the hands of private traders, placing it in the uninspired care of bureaucratic negotiators.

Our government has taken the lead in calling the conference of 18 nations, now meeting at Geneva, to open as many trade doors as possible. The American delegates will bargain product by product and country by country—all summer, if necessary—for lower tariffs, fewer quotas and a free flow of *private* trade. The task is a long one, and the results are as yet uncertain, but, if success is achieved, an immense opportunity for good works and good earnings will be before American businessmen.

This is no picayunish opportunity. Authoritative estimates put our 1947 exports at $11 billion and our imports at $6 billion. That's substantial. It is greater than the value of all crops grown on our farms ($10½ billion) and exceeds the value of all shipments of industries such as automobiles ($9 billion), textiles ($8 billion) and chemicals ($8 billion).

International trade is vital, not to be shrugged off, not to be kicked around as a football of party politics. Republicans and Democrats agree on a non-partisan foreign political policy. They should agree also on a non-partisan foreign *economic* policy. The foreign relations of the United States, political or economic, can no longer be log-rolled hither and yon.

A general program for international recovery, outlined here, will bring its full quota of aches and pains. But lack of a program will produce economic and political troubles on a vast scale; timid retreat will invite economic disaster and war.

By an intelligent, bold and resourceful program, we have a chance to win through to a long peace in the kind of world we want. *Unless America provides the leadership, there can be no such program.* Then Communism merely needs to hang around long enough to pick up the pieces.

Ours is the responsibility and the opportunity.

James H. McGraw, Jr.

President McGraw-Hill Publishing Company, Inc.

THIS IS THE 58TH OF A SERIES

A NEW ENTERPRISE

Advocacy by the McGraw-Hill Publishing Company, in the accompanying editorial, of an effective world economic policy is not a mere verbal exercise. In the faith that we as a nation shall develop such a policy, this Company, following a trail blazed by leaders in American industry and finance, is expanding its operations overseas.

A newly created McGraw-Hill International Corporation will push forward the frontiers of our technical magazine and book publishing business throughout the world. The new Corporation comprises:

Eight international magazines—the McGRAW-HILL DIGEST, THE AMERICAN AUTOMOBILE and EL AUTOMOVIL AMERICANO, PHARMACY INTERNATIONAL and EL FARMACEUTICO, INGENIERIA INTERNACIONAL CONSTRUCCION, INGENIERIA INTERNACIONAL INDUSTRIA, THE MACHINIST.

A newsgathering agency, McGRAW-HILL WORLD NEWS, specializing in industrial and engineering coverage with correspondents in 36 world centers.

McGraw-Hill Publishing Company, Ltd. (London), serving the special needs of Britain and western Europe and publishing THE MACHINIST (London).

Free buyers' guides—AUTOMOTIVE EQUIPMENT (in English and Spanish), CONSTRUCTION EQUIPMENT, INDUSTRIAL MACHINERY and PHARMACEUTICALS (all in Spanish).

In addition, the McGraw-Hill Book Company has an overseas network for the distribution of its books.

New Craft Join Jet Ranks

This model previews giant Northrop all-jet Flying Wing bomber now rapidly nearing completion. Total of 32 000 lb. static sea level thrust will be generated by craft's eight GE J-35 (TG 180) axial-flow turbojets, shown here grouped in fours, with tail pipes projecting between four vertical "air separators" at wing's trailing edge Separators aid directional stability To carry a crew of 13, new AAF bomber will have a span of 172 ft. and length of 53 ft. (Press Assn. photo)

First photo received showing USSR's reaction-propelled aircraft depicts interesting mid-wing craft flying at Soviet air demonstration. Jet intake is in nose, exhaust beneath fuselage Close examination indicates that power installation comprises two turbojets fitted side-by side. (Sovfoto)

Although no information was supplied, this picture from USSR shows a Russian piston-engined fighter apparently fitted with a rocket unit for short bursts of acceleration on order of a Jato installation Further photos showed other Soviet craft with similar units under wings (Sovfoto)

Stanley Hiller, Jr. is seen hovering an experimental 'copter of his design utilizing a tail jet for rotor torque compensation First flown last August craft is stated to be solely a test project, no production being considered at present Directional trimming is said to be obtained by drawing off a portion of airflow through a bleeder valve on ft side of fuselage Vanes are set vertically in jet exhaust orifice at selage seat A two-bladed rotor is fitted Company is reported to be at work on jet-driven 'copter.

North American's new XB-45 medium bomber displays clean lines despite its size. Range and payload are said to exceed those of comparable World War II heavies. Flaps and tricycle landing gear are hydraulically actuated, with trim tabs worked electrically. Hydraulic boosters on elevator, ailerons, and rudder supply 95% of energy needed to activate these controls. Note large degree of dihedral on horizontal tail surfaces. NAA has contract for 90 of these craft. Closeup shows craft's entire forward portion, including mounting of twin sets of turbojets in each wing. Crew entrance door may be seen just forward of bubble canopy.

North American Grooms XB-45 J-P Bomber

Speedy four-placer now being proved by AAF is powered by four GE J-35 turbojets cpable of 16,000 lb. tutal thrust.

Detailed here is side-by-side positioning of powerful J-35 turbojets, with landing light mounted between them. New narrow high-pressure tire was especially designed to retract entirely into XB-45's thin wing.

With acceptance of North American Aviation's new XB-45, the AAF has added still another all-jet bomber to its growing roster of this type. The new craft is now undergoing trials at Muroc Air Field, and on its first successful test flight remained aloft 1 hr 4 min.

Patterned along conventional lines, the XB-45 is a highly streamlined four-placer powered by four GE designed Allison built J-35 turbojets, each capable of 4,000 lb thrust at sea level. The engines, arranged in pairs in single nacelles in each wing, are mounted entirely ahead of the leading edges for ease of accessibility and maintenance.

Crew members are housed in pressurized cabins. And since the craft is designed for very high speeds, only the bubble canopy marking the tandem positions of pilot and co-pilot protrudes above the fuselage. Because of the craft's high performance, heat in the cabin, generated by skin friction, would make crew members uncomfortable at low altitudes if there were no cooling system. A refrigeration unit installed in the XB-45 is reported capable of reducing inside temperatures 30 deg below outside temperatures. An air control system permits crew members to mix hot and cold air so as to obtain comfortable temperatures at all times.

Spanning 89 ft 6 in., length is given as 74 ft ¾ in., and height to tip of rudder as 25 ft 1 3/16 in. Although classified by the AAF as a medium bomber, plane compares in size and range to a wartime "heavy", moreover, its payload is stated to be substantially greater.

Novel Four-Place Satellite Readied in Britain

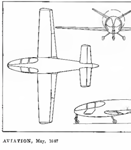
Constructed by a new company, airplane features all-magnesium fabrication, a behind-tail pusher prop, and also a butterfly empennage.

A NEW FOUR PLACE British personal plane, embodying unusual design and construction characteristics, is now nearing completion, with expectations of flight tests at an early date.

Named the Satellite, the prototype is being built by the newly formed Planet Aircraft, Ltd. It is a low wing pusher having a butterfly tail and pusher prop. Fabrication is of an all-magnesium base alloy containing zirconium. However, we are told that precise composition of alloy to be used in production models has not yet been determined.

A 252-hp. DH Gipsy Queen 31 engine is being fitted to the Planet, to turn a 77-in. two-bladed propeller, said to be of the new DH manually controllable pitch type. The engine, placed just behind the rear pair of seats, will drive a transmission shaft approximately 7½ ft. long. Cooling is to be handled by an engine-driven multi-blade fan, and the air entry duct is located on top of the fuselage.

Dimensions are given as follows: Span 33 ft. 6 in., length 22 ft. 2 in., height 9 ft. 2 in., tread 6 ft., wing area 153 sq. ft., ailerons 11.2 sq. ft., flaps 18 sq. ft., and tail 41 sq. ft. Empty weight is given as 1,470 lb., and gross as 2,800 lb., including 200 lb. of baggage. Estimated performance figures are: Top speed 200 mph., cruising 180 mph., stalling speed 60 mph., rate of climb 1,000 fpm., and service ceiling 14,000 ft. Takeoff run without wind is gaged at 150 yd.



The wings are being built up of widely spaced ribs and varying thickness skin, with a spanwise member in front of ailerons and flaps. Wing skin thickness is stated to be 2 in. at the root, then diminishing, as aerodynamic loads decrease, toward the tips. Upper skin is thicker than bottom skin. It is said that the wing is made in components in the form of a series of torsion boxes, which are welded together. Fuel tanks, of 28 gal. capacity each, are integral with wing roots on each side of the fuselage.

Fuselage is constructed in two sections, the joint being made at the wing trailing edge. A magnesium girder built in the form of a keel runs along the fuselage bottom and acts as a firm support for tricycle landing gear. All wheels retract into fuselage. Main gear uses a spring-leaf type shock absorber. Pneumatic operation is being used for actuation of landing gear and flaps.

Specifications and Data

Span	33 ft. 6 in.
Length	22 ft. 2 in.
Height	6 ft. 2 in.
Wing area	153 sq. ft.
Tread	6 ft.
Empty weight	1,470 lb.
Gross weight	2,800 lb.
Top speed	200 mph.
Cruising speed	180 mph.
Stalling speed	60 mph.
Rate of climb	1,000 fpm.
Service ceiling	14,000 ft.
Seats	4
Power	252-hp. DH Gipsy Queen
Propeller	77-in. DH manually variable pitch

Fleetwings Navy Bomber Revealed

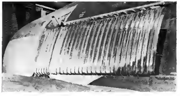
Concealed wartime project, designed for small flat-tops, is disclosed as potent and fast tactical type.

Shown during test flight, Kaiser Fleetwings XBTK-1 displays clean design and neat workmanship. Its high performance (350-plus mph) is credited to extreme care in planning weight control, typical example being hydraulic system operating flaps and brakes, same actuating mechanism being used for both.

Designed and built near the end of World War II, the hitherto secret Kaiser Fleetwings XBTK-1 single-place dive torpedo bomber did not get into production—although four of the craft were completed and flown before Navy terminated the contract.

Engineered for use on small escort carriers, it is stated to have embodied exceptional handling qualities. And powered by a 2,100-hp P&W R-2800-34 W Double Wasp turning a 13-ft. 4-in. Hamilton Standard Hydromatic propeller, the craft is revealed to have been in the 350 plus-mph class. In addition to the normal complement of four 20 mm. cannon, the XBTK-1 could also be fitted with over 5,000 lb. of either bombs, rockets, torpedoes, and mines, or radar gear and auxiliary fuel tanks.

Of all metal construction, it was planned for easy servicing, with hydraulic and electrical equipment placed under the cockpit floor and readily accessible through the wheel wells and detachable side panels. Normally grossing about 15,000 lb., plane measured 48 ft. 8 in. in span, 38 ft. 9 in. in length, and had width (with wings folded vertically) of 20 ft.



Detailed here is left exhaust duct, which also acted as a flame dampener. Craft used engine exhaust gases to cool engine by pumping air through nose entrance and passing it out ducts, thus obviating necessity for cowl flaps, also improving streamlining and visibility.

XBTK-1's unique dive brakes. Upper portions nestle into wing, while lower sections retract into bottom of landing flaps. Flaps of slotted type run across fuselage bottom.

Searching Drag Studies Check Speed Impeders

PART I

Of considerable interest to aircraft designers are results of drag-investigations* of twelve military planes tested in NACA's Langley full-scale wind tunnel, to determine undesirable aerodynamic characteristics.

In most cases, large reductions in drag were found to be obtained by careful detail design, also by relatively simple modification to existing designs.

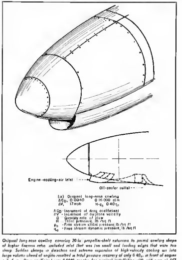
Standard procedure with each of the craft investigated was to evaluate drag of as many component items and installations as was feasible. This evaluation was accomplished by determining drag of the plane in successive conditions—from a faired and sealed smooth craft to the service status. If excessive drags were discovered, attempts were made to determine improvements possible within practical limits. Many of these modifications indicated good design methods for treating similar items on other craft.

Individual drag of many details investigated was found to be small, but sum of these drag effects would considerably decrease airplane speed. Velocity decrements were calculated for craft tested at maximum level flight speeds, and accordingly will become greater as speed increases. Certain installations, such as cylindical protrusions and refaired bulges, may have greater drag at full speed flight than wind tunnel measurements indicate because of compressibility effects.

Usual procedure in the tests was first to fair or remove all protrusions on the plane and seal all points where air leakage was suspected. With the craft in this condition (referred to as sealed and faired condition), a force test was made at tunnel airspeed of 100 mph to determine drag in the high speed attitude. Seals and fairings were then progressively removed and drag increment resulting from each change was determined. In some cases, the order in which seals and fairings were removed affected amount of drag measured, and in all tests attempt was made to isolate as many drag items as possible.

Cowlings and ducts were tested with inlets and outlets sealed and then opened (high speed condition), so that drag resulting from cooling-air flow thus could be determined accordingly.

Results of the investigations demonstrate that worthwhile drag-reductions can be obtained by relatively simple sealing and fairing modifications



Original long-nose cowling covering 20-in. propeller-shaft extension to permit cowling shape of higher fineness ratio included inlet that was too small and leading edges that were too sharp. Sudden change in direction and extreme expansion of high-velocity cooling air into large volume ahead of engine resulted in total pressure recovery of only $0.40q_0$ in front of engine cylinders. Drag coefficient was 0.0040 greater for original installation with exit area of 167 sq. in. (cooling flaps in closed position) and air flow quantity of approximately 16,000 cfm at 350 mph. than for sealed and smooth cowling with scoop removed.

* Summarized by Roy H. Lange

Elimination of leakage and attention to detailed design appeared to offer best possibilities for drag reductions on craft that are otherwise relatively clean aerodynamically.

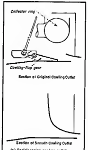
Noted on the illustrations used in this series to depict original installations, together with modifications investigated, are drag increments measured during each test, also corresponding decrements in maximum speed.

This first installment of a series presents, in sketch-and-caption form, a study of cowling drag factors.

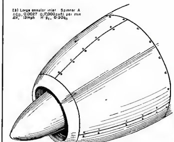
→

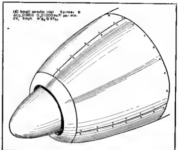
Next tested was cowling with annular inlet and 0.25 inlet-velocity ratio designed to reduce kinetic-energy losses of cooling air and avoid large external drag of original cowling (c). Compared with sealed and smooth cowling with scoop removed, airplane drag coefficient was increased to 0.0022 with an air flow of approximately 12,000 cfm., and to 0.0027 with approximately 17,000 cfm. air flow. Pressure measurements along spinner (A) indicated flow reversal caused by high adverse pressure gradient. Total pressure at rear of diffuser was slightly less than $0.90q_0$ for these conditions.

Drag of annular-inlet cowling with spinner (A) was considered excessive and outlet was next investigated. Removing cowling-flap gear and exhaust collector ring and installing smooth outlet decreased cowling drag by 0.0007, with air flow of approximately 13,000 cfm. Also, bottom exit was provided by removing oil cooler and enlarging cooler exit to allow engine-cooling-air flow of approximately 13,000 cfm. with cowling flaps sealed. This arrangement further reduced drag by 0.0004. ↓



(c) Radial-engine cowling outlet





To reduce adverse pressure gradient along spinner (A) and to increase total-pressure recovery in diffuser, inlet-velocity ratio was increased to about 0.5 on spinner (B) by increasing spinner size, thus reducing annular-inlet area. With bottom exit open and cowling flaps sealed, cowling drag coefficient was reduced 0.0005 as compared with that measured with spinner (A) and same outlet, and air flow was increased to approximately 14,000 cfm. Cowling flaps were then unsealed and air flow increased to approximately 21,000 cfm.—sufficient for engine, carburetor, and oil cooler. Cowling drag coefficient of 0.0012 measured for this arrangement was lowest obtained in Langley full scale tunnel tests of cowlings for radial air-cooled engines. Pressure measurements over cowling indicated that critical Mach number was 0.74.

Cathode Tube Improves Compass

Determining bearings by an electron beam instead of a magnet, new electronic compass operates to correct progression of directional gyroscope. It does not have northerly turning error of needle compass, its lag is negligible, and accuracy is within 1 deg. Additional uses are noted.

To provide accurate bearings with relation to the earth's magnetic field, a compass using an electron beam as sensing element has been developed. Basically it is a cathode-ray tube the electron beam of which is deflected by an external (terrestrial) magnetic field. The electron beam strikes four target plates. Depending on the external magnetic field, more electrons strike one plate than the others—producing a distribution of current from the four plates and thus indicating orientation of the tube in the magnetic field. The compass tube, or Cathotrol, was developed by Minneapolis-Honeywell Regulator Co for use with its electronic autopilot.

The Cathotrol is mounted on gimbals so as to hang vertically, as shown in Fig 1. It can be connected for the purpose of (1) remotely operating a compass indicator or an autopilot, (2) to determine dip and latitude, (3) to measure intensity as well as direction of magnetic fields, in which function it can be used in geophysical prospecting, (4) to detect field changes as small as one-half milligauss; or (5) to control large coils to produce a magnetically field-free space

As an aeronautical compass, the Cathotrol is advantageous in that it uses no iron that might distort the earth's magnetic field or become magnetized or demagnetized, it has no northerly turning error, as found in needle compasses (although when flying north with a slave autopilot the system hunts slightly), and the electron beam has negligible time lag (a factor of importance at supersonic speeds). Because the output signal is linear with magnetic field to flux densities beyond the maximum horizontal component of the earth's field (the component to which the Cathotrol is sensitive), this electronic compass easily measures bearing to plus or minus better than 1 deg throughout 360 deg, is sensitive to changes of bearing of less than 0.25 deg, and can operate through an autopilot to hold a course with a consistency considerably better than 1 deg Variation of power supply voltage up to 25% changes the indicated bearing less than 0.5 deg

Construction and Operation

Fabrication of the Cathotrol can be seen from Fig 2 At the top right is the electron gun. Rather than use a gun construction of the type developed for conventional cathode ray tubes, a compact construction was developed using more but smaller electron beam forming electrodes. The gun provides a higher current beam than in conventional cathode-ray tubes Very little of the initial beam current is lost in passing through the gun, and a beam of greater diameter is produced than in cathode-ray tubes designed for use in oscilloscopes and television receivers. The gun operates at about only 300v. instead of the several thousand volts of conventional electron guns, and is less affected by changes in supply voltage. The electron beam strikes target plates that form equal quadrants of a circle Operation of the Cathotrol can be followed with the aid of Fig. 3. Electrons from the cathode are modulated by the grid to form a 400 cycle per second alternating current. This electron-beam current is focused by the electron gun into a broad spot on the target plates. The voltage divider provides proper voltage for the electron gun In order that the number of flexible leads at the gimbals can be a minimum, thus voltage divider is mounted directly on the tube

Centering electrodes placed along the path of the beam are used to direct the beam (in a magnetically field-free space) to the center of the target plate area. The centering electrodes compensate for inaccuracies in aligning the gun, thus simplifying tube construction. The target plates actually overlap one another so that electrons cannot pass on to the glass envelope beyond the plates, where they could accumulate and establish random charges that would deflect the beam The glass envelope has a conducting inside coating to further assure that no stray charges will form to deflect the beam Thus only an external magnetic field will bend the beam Connections into the tube are made through loctal bases at either end The tube and its sockets are floated on rubber inside its nonferrous mounting The necessary voltage supply for the tube's operation, and the amplifiers used with it, are housed on a remotely located chassis.

With the beam centered on the target plates, electrons are reaching each plate at equal rates—that is, equal currents pass in opposing directions through transformer primaries (as shown in Fig 3) and so give no output. If, however, the Cathotrol is suspended vertically in the earth's magnetic field, the beam will be deflected to the west. Thus unequal currents flow from diametrically opposite target plates, and signals are produced in the transformer secondaries The signals so developed by the Cathotrol are resolved into directional components and fed to the progression motor of a directional gyroscope. The Cathotrol thus acts on a directional gyroscope in much the same fashion as the gravity erection system of a vertical gyroscope.

Progression of the directional gyroscope (and rotation of the earth or latitude effects) forces the plane from its course through its control of the autopilot. The Cathotrol mounted in a wingtip is then moved with respect to the earth's magnetic field so that it develops an output signal that is fed back to the precession motor of the gyroscope to correct it, thus returning the plane to normal (At the same time that the directional gyroscope is rotated, potentiometers can also be rotated to introduce balancing voltages in the Cathotrol output In this way the system becomes self-centering, and can be set externally, through these potentiometers, to follow any desired course.)

Although directional signals from the Cathotrol are not instantaneously correct because of accelerations of the airplane, they have an accurate average, the gyroscope acting to integrate the signals to obtain this average. During long time accelerations, the precession motor is switched off If the tube is tilted from its vertical position, it will, of course, respond to the horizontal component of the earth's magnetic field and thus give an erroneous indication, the amount of error depending on the local angle of dip.

The cathode-ray tube compass has been used to operate a slave gyroscope and autopilot on flights covering several thousands miles in several airplanes It has maintained heading over long periods and shown its ability to determine accurately changes in heading through the autopilot.

Fig 1. Cathode-ray tube compass (right) is housed in nonferrous shield and suspended in gimbals. It is of about 1 in. dia and 7 in. long. Compass indication can be given at remotely located indicator (left) and to autopilot

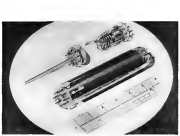


Fig. 2 Compass tube consists of electron beam gun (top, right) and multiple target (top, left) housed in glass envelope. It weighs 1.5 lb.

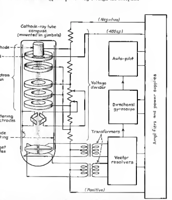
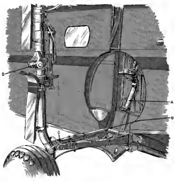
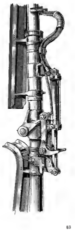


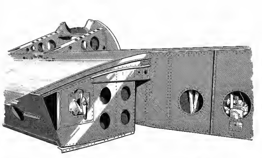
Fig 3 When electronic compass tube is suspended vertically, earth's magnetic field deflects electron beam to west. Signal so produced is fed to vector resolvers to develop directional output, which controls autopilot through directional gyroscope and operates pilot's compass indicator

Grumman Mallard



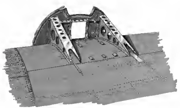


Main landing gear of Grumman Mallard amphibian is retracted by hydraulic jack (A) with wheel being swung up and inward through pivot points (B) and (C) and (D)—at which point downlock is located—and at wing attachment point. Hydraulically operated landing gear downlock is shown in detail sketch at right.

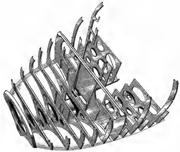


Left side of part of Grumman Mallard wing center section, looking forward toward rear face of box beam around which wing is built. Extrusions are used for beam cap strips and transverse bottom stringers, while lighter bent-up sections are used on top. Trailing edge sections (shown here) extend outboard from hull line and are made up of stamped supporting ribs covered with stressed skin, with attachment to box beam by means of rivets and screws. Leading edge section from hull line outboard to engine nacelle frames are attached with screws so as to be removable for access to installations on front face of beam.

Grumman Mallard



Looking forward over Mallard wing toward frame for supporting engine nacelle structure. This unit, built up of aluminum ally sheet assemblies, is riveted to leading edge section of wing.

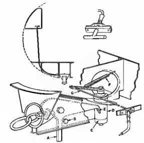


Grumman Mallard

Lower forward hull structure of Grumman Mallard showing various types of bulkheads employed in this section. Keel and chine members throughout the semi-monocoque fuselage — hull structure are heavy extrusions covered with stressed skin plating.

Messerschmitt Me-163

Cutaway sketch depicting details of tow coupling for Messerschmitt Me-163, with coupling lever (A), stop screw (B), journal guide (C), locking bar (D), locking cam (E), locking spring (F), and its release (G). Detail sketch at top left shows method of leading bowden cable from cockpit and sketch at upper right shows release grip in cockpit.



Novel Lift Devised To Ease Battery Change

Mobile ground servicer—combination battery platform and hoist —is developed by EAL personnel to cope with hazardous and difficult task of installing batteries on large craft.

To eliminate back-breaking effort entailed in changing aircraft batteries by hand, a practicable lift has been devised at Eastern Air Lines' Miami operations and maintenance base.

Designed by Electrical Foreman George Freeman, in conjunction with other employees, lift makes it possible to discard the practice of climbing a ladder and lifting 70-80 lb batteries prior to sliding them into receptacles installed in large craft. And in addition to eliminating danger of strains and serious injuries to battery-changing personnel, the lift reduces change time by approximately two-thirds for an average number of 124 daily replacements.

Essentially the device comprises a three-wheeled platform combined with a hoist. Platform holds six batteries—sufficient to service three craft—and hoist extends sufficiently high to reach the battery compartment of Douglas DC-3s and DC-4s and the Lockheed Constellation. Hoist can also be lowered into horizontal position, to facilitate movement of entire unit on the ramp.

Two metal arms, wide enough to hold a battery, are attached to the hoist, and handcrank-and-chain arrangement makes it possible to easily raise the battery. The hoist can be tilted back to permit battery to be lifted to the level of the battery receptacle, then tilted forward for battery to be lowered into position. When weight of the battery is taken off the arms, they slide away freely and can be cranked down.

A dead-man control, built into the crank handle, automatically applies brakes should the operator's hand slip off the handle, thus preventing possibility of the heavy battery coming down the hoist too fast.

Ease of installing and removing 70 to 80-lb. battery in large craft is demonstrated by EAL's Electrical Foreman George Freeman (left) with his newly invented lift, as A. L. Chabot, line's assistant maintenance superintendent, looks on. Device simplifies task by eliminating need for ladder or hand lifting. Photo right: For comparison with new lift's ease of operation, Mr. Freeman demonstrates difficulty involved in former hand-change method for battery units—a procedure entailing distinct risk of personal injuries.

Dome Protection Assured In Prop-Balancing Procedure

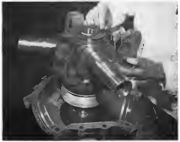
■ Rubber strips installed on end pieces and supports of knife edge on balancing stand in PAA's La Guardia Field prop shop eliminates possibility of domes being scratched as propeller is lowered into place Strip installation was suggested by Mechanic Pete Di Liberto.

Prop Template Saves Shop Servicing Time

■ This template, devised by William R. Smith of PAA's metal shop, fits over propeller blade to fix boundary for application of primer and rubber cement for anti-icing Device allows 30-min time saving each time prop is serviced

Small Job Jig Speeds Bench Welding

• This set-up jig, standard equipment for each welding bench at PAA's La Guardia base, was devised by Arthur Foster Found to be a substantial time saver adaptable for small welding jobs, jig consists of pair of prongs with comparatively heavy forked legs Prong not seen in photo holds job at point where it rests on brick



Simple Shim Devised To Hold Prop Spider Blocks

• To solve problem of retaining spider assembly Micarta blocks when barrel halves of propeller hub are lowered, this brass ring shim was devised by Vincent J. Lombardo of PAA's prop shop Ring fits over hub top section and carries three $\frac{1}{8}$ in dia wire circlets just long enough to fit snugly over blocks and hold them in place. Circlets are easily adjusted by hinging effect at attachment holes on ring. Individual circlet is raised to permit work behind any one Micarta block, leaving others hugging spider.

Factors in Helicopter Economics

By **RAYNOR F. STURGIS,** *Consulting Engineer, Booz, Allen & Hamilton*

Presenting data on rotory-wing craft construction and maintenance costs, the author points out the necessity of increasing payload and simplifying design in order to get helicopters on an operations par with fixed wing transports.

SUCCESSFUL flight performance by helicopters developed by Focke-Achgelis and Flettner in Germany, Breguet in France, and a dozen or more companies in the United States, have conclusively paved the way for an active role in years to come for this most maneuverable of aircraft With a high degree of safety and control, helicopters have proved their ability to fly forward or backward, ascend or descend vertically, hover over a given point, or make power-off landings at negligible forward speeds

The helicopter's usefulness has been established in numerous governmental activities such as air sea rescue, military observation and supply, and forest fire control, also for commercial activities such as exploration and prospecting, crop dusting, and other specialized activities Successful experiments by the Post Office Dept may soon permit utilizing helicopters for airmail service for residents of suburban areas surrounding our larger cities. The questions, then, are When can the helicopter begin to furnish the traveling public with short-haul helicopter passenger service, and when can the public afford to pay the fare?

On airline flights between New York and Boston, Philadelphia and Pittsburgh, Cleveland and Detroit, Chicago and St. Louis etc, ground travel to and from the airport at each end of an airline trip can consume as much time as the flight itself Helicopter taxi service between suburban and downtown areas and municipal airports could cut 50 to 75% from this present excessive ground travel time, thus saving up to half the time now consumed on airline trips on these heavily traveled routes. Expressed in another way, the potential saving in time, using helicopter short-haul service, would be equal to more than doubling the cruising speeds of the most modern airliners.

Limousine fares to and from airports are about twice as much as airline rates per passenger-mile If a passenger need pay no more than this present limousine rate of 10¢/mi for helicopter taxi service, he would thus break even on fare and could save half the time presently necessary for a large percentage of his air travel Accordingly, he could not only be expected to welcome helicopter taxi service, but also might use airlines much more often for city-to-city trips of less than 1,000 mi

To examine and compare factors which contribute to operating costs of existing helicopters, it has been felt necessary to tabulate the weight of each helicopter's components, assign to them average estimated cost figures, and evaluate each model's manufacturing and operating costs by means of ATA's formulas, modified for helicopter data (Fig 1).

Different U S manufacturers' models, as well as foreign machines, are of widely varying designs Sikorsky, Firestone, and Bell each use a single main rotor configuration with a torque compensating rotor, yet Bell uses a 2-bladed, tilting rotor system, whereas Sikorsky and Firestone use 3-bladed, articulated blade rotor systems Platt Le Page, McDonnell, and Focke-Achgelis use twin three-bladed rotor systems, with articulated non-intermeshing rotors mounted outboard on either side of the fuselage Flettner and Kellett models have 2- and 3-bladed rotors, respectively, with twin rotors intermeshing near the blade roots Piasecki uses an articulated 3-bladed twin rotor system, with rotors fore and aft Hiller, Bendix, and Breguet use 2- or 3 bladed rotors, rigid or articulated, with twin rotors mounted coaxially Many additional design configurations show promise and accordingly are being developed at the present time Yet no one of these designs shows outstanding promise of lowering the average manufacturing cost, or average operating cost, of any class of helicopter—either 2-place, 5-place, 10-place, or larger size While single-rotor designs are about 10% less expensive than twin-rotor types for equal power, for example R-6A vs XR-8, and S-51 vs. XR-1A, it can be assumed that the most satisfactory avenue for cost reduction will be some revolutionary simplification of design, followed by mass production manufacturing methods Thus, considering prices of the two helicopters presently certificated by the CAA, and now being manufactured for commercial use, Bell's 2-place Model 47 may be considerably reduced from its reasonable initial $25,000 figure, and Sikorsky's 4-place S-51 from its $48,500 figure.

Remarkable as this cost reduction may become, the *average* person would still be limited to buying helicopter travel by the mile, not by the year. He can afford to pay a dollar to fly in 10 min to the airport 10 mi away, but he can't afford to own a private helicopter costing $10,000, and he can't afford to operate it

To determine potential operating costs of today's helicopters, and to prophecy what can be expected of tomorrow's developments, a chart (Fig 2) has been prepared to show how operating costs decrease as payload increases. The average operating cost

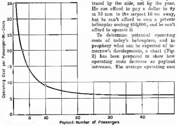


Fig 2 Calculated helicopter operating costs. Charted here are number of passengers vs cost/passenger-mile at a 60-mph. block speed, 25-mi trip and 90-mph. cruising.

per passenger-mile for the present 2-place machine, with room for one passenger in addition to a professional pilot, comes to 35¢/mi. For a 4- or 5-place machine, the average operating cost/passenger-mile is estimated as 16¢; for the 8- to 11-place machine, 9¢/passenger-mile; and for the next logical development of the future, a 40-place helicopter, with either conventional power plants, or gas-turbine plus jet-driven blades, 6¢/passenger-mile.

Assuming that helicopter transport companies would be no less efficient than present airline companies, and would therefore operate at approximately a 100% overhead figure, fares of 70¢/passenger-mile for 2-place, 30¢/passenger-mile for 4-place, and 18 to 20¢/passenger-mile for 10 place helicopters would result. By meeting the limousine rate of 10-12¢/passenger-mile, profitable operation would become possible when current 40-place helicopter development programs reach successful conclusions.

Capacity-wise, these 40-place helicopters would properly complement the 40- to 60-place airliners now on production lines. A high average load factor appears reasonable, since fuel requirements for short taxi trips to and from airports would permit round trip return flights utilizing close to 100% payload capacity. Cost-wise, revolutionary design simplification programs for such 40 passenger helicopter transports should be deferred until completion of engineering development programs for providing utmost passenger convenience and safety, and in increased cruising speeds. Importance of this increased cruising speed factor is noteworthy, since a further 50% reduction in operating cost should be realized for helicopter transports as block speeds increase. (See Fig. 1, where for a 25 mi. trip, block speed is 60 mph for helicopters with 90-mph cruising speeds. This block speed doubles as cruising speed increases from 90 mph to 150 mph.)

To conclude, engineering refinements which would cause the cost of all-metal helicopter transports to stay above the $10 per pound average cost of all-metal fixed wing transports, would be welcomed by operating companies where accompanying increases in block speed would permit decreasing fares to as low as 6 to 6¢/passenger-mile figure needed to place them in service throughout the country. The air traveling American public is waiting for a chance to buy economical transport helicopter service.

Helicopter Estimated Operating Costs

	Sikorsky R-6A	Bell 47	Kellett XR-8	Firestone XR-9B	Platt LePage XR-1A (PL-?)	Sikorsky S-51	Bell 42	McDonnell	Kellett XR-10	P-V Eng. PV-3	Project	Project
Passengers	1	1	1	1	1	3	4	10	11	8	40	40
Empty weight	6 019	1,800	2 132	1,939	4 040	3,090	3 400	8 250	8 540	4 259	23 270	12 450
Useful load	574	600	588	811	1 140	1,200	1 600	2 750	3 002	3 141	10 730	13 530
Payload								2 000	2,200	1,900	8 908	8,000
@ Fuel load								34 gal.	—	50 gal.	—	700 gal.
& Range								85 mi.		50 mi		75 mi
Gross weight	6 660	2,300	2 779	2 750	5 180	4 300	4,900	11 000	11,400	6,420	34 000	26 000
Engines, number	1	1	1	1	1	1	1	2	2	1	2	1
Make	Frank.	Frank.	Frank.	Lyc.	P&W	P&W	P&W	P&W	Cont.	Cont.	P&W	
Rated hp., each	245	175	245	135	450	450	450	450	525	325	2 300	1 875+Jets
Weight, power plant	488	425	489	327	772	772	772	1 380	1 592	879	4 830	1 835+Jets
Cost, est. @ $5/lb.	$2,445	$2 125	$2 445	$1 635	$3 860	$3 860	$3 860	$7 155	$8 460	$4 395	$24 150	$9 555
Weight, transmission	175	125	152	215[3]	716[1]	450	292	1 607	1 201	680	4 600	—
Cost, est. @ $14.5/lb.	$2,082	$1,615	$2,204	$3 132	$10,382	$6 525	$4,234	$23,302	$17,414	$9,860	$66 700	—
Rotor diameter	38	35	38	28	32 8	49	47	48	38	41	90	100
Blades, number	3	2	6	3	6	3	3	6	6	6	6	3
Weight, blades	150	250	208	136	242	375	400	800	987	380	1 080	2,680
Cost, etc. @ $15/lb.	$2 098	$3 750	$3 870	$2,800	$3 330	$5 080	$6 000	$12,000	$14,805	$5 400	$55 160	$40 200
Weight, rotor mechanism	140	85	341	—[2]	178[1]	220	200	450	784	163	1 270	600
Cost, etc @ $14.5/lb.	$1,960	$1,233	$4,946		$2 581	$3,190	$2,900	$6 162	$11,318	$2 320	$18,588	$31 600
Weight, instrument and radio	60	60	60	60	60	100	100	100	100	100	100	100
Cost, est. @ $38/lb.	$2 280	$2,280	$2 280	$2 280	$2,280	$3,800	$3 800	$3 800	$3 800	$3 800	$3 800	$3 800
Weight, airframe balance	1 032	555	523	538	2 188	1 732	1 436	3 337	3 827	2 000	12 800	8 900
Cost, etc. @ $7.5/lb.	$7,730	$4 163	$3 922	$4 020	$15 310	$12 990	$10 770	$25 778	$28 702	$15 000	700 000	$66 750
Cost, etc. total	$18 842	$15,364	$21 016	$13 567	$39 563	$35,005	$34 464	$80 797	$84 104	$41 270	$240 615	$151 645
Inst. sales price (est. × 1.50)	$28 250	$22,600	$32 500	$19 400	$59 500	$54,000	$51,900	$121,900	$127,000	$61,900	$361,000	$228,000
Actual price	$47,000	$28,000	—	—	—	$48,900	—	—	—	—	—	—
Calculation Detail												
Depreciation, airframe	$6,800	$2,365	$3,090	$1,700	$6 860	$4 590	$4 790	$10 200	$11 000	$8 700	$62 700	$14 900
Depreciation, engine	839	373	380	635	1 290	1,300	1 442	2 916	6 170	1,890	9,000	6 600
Depreciation, transmission	600	838	800	800	2 013	600	1 141	6 300	1,700	2,700	20,700	—
Depreciation, blades	2 000	5 250	6 100	2 300	5 450	7 600	11 750	18 000	22 200	9 110	27,500	20 000
Depreciation, annual total	8 298	8,824	10,898	5,511	18,840	14,440	19 073	37 410	38 970	18 408	99,960	42 800
(Use, 2,000 hr @ 600 hr. std.)	660		660			840						
Overhaul, engine (labor)	1 300	600	1 300	340	840	2 100	840	840	1,754	840	11,200	6 800
Overhaul, engine (material)	880	1,600	880	700	2,150	800	2 150	2 150	4 600	2,160	8,800	2 790
Overhaul, transmission and repair	2 160	825	1 515	980	1 300	3,150	700	2,800	1 380	1 300	7,500	—
Overhaul, aircraft, (lab. and mat.)	6 130	1 370	6 136	1 050	4 200	6,280	6 600	6 350	6 250	4,370	14 300	6 130
Ground service	1,460	5 150	1,800	3,800	6 760	2,430	6 340	13 000	13 740	6 760	11,200	13 330
Engine repair (lab. and mat.)		1 250		960	2 980		2 430	4 890	3,980	2 420	5,550	5 720
Maintenance, annual total	12 880	10,856	11 720	6,660	17 460	16,210	15 300	30 280	33 344	17 450	67,380	35 880
Pilot insurance	768	768	768	765	768	768	768	765	768	168	768	115
Public liability	2 880	2,880	2 880	2 880	2 880	2 880	2 880	2 880	2 880	2 880	2 880	2 880
Public insurance	2,520	2,520	2 520	2 520	2,520	7,600	10 200	27,700	27 800	20 150	100,000	100 000
Cargo insurance												
Insurance, total	6,168	6,168	6 168	6 168	6,168	11,209	13 845	31 345	31 345	23,79'	140,645	103 645
Fuel	4 400	3,150	4 400	2 420	6 100	6 100	8 136	16 200	16 900	8 100	82,300	79 000
Oil	276	200	276	151	510	507	336	1 016	1,240	810	8,130	3,000
Fuel and oil, total	4 676	3,350	4,676	2 571	6,610	6,607	8,510	17 210	21 080	8,900	91,000	82 000
Operating Cost Summary												
Depreciation	$8 298	$8 824	$10 898	$5 511	$18 840	$14 440	$19 073	$37 410	$38 970	$18 408	$99 960	$80 460
Maintenance	12 360	10 555	11,745	6 330	17,490	16,310	15 300	30 280	33 944	17 490	67,380	35 340
Insurance	6 165	6,165	6 158	6 136	6,136	11,209	13 845	31 345	31 345	23 795	140 645	103 645
Fuel and oil	4 676	3 350	4 676	2 571	6 610	6 607	8 510	17 210	21 040	8,910	91,000	82 000
Pilot @ $8,000/800 hr	24 000	24 000	24 000	24 000	24 000	24 000	24 000	24 000	24 000	24 000	24 000	24 000
Total oper. cost/2 400 hr	$55 308	$53 004	$57 482	$47 927	$71 308	$74 742	$81 188	$140 245	$148 299	$92 300	$373,148	$329 055
Total oper. cost/hr	$23	$22	$24	$20	$30	$31	$34	$58	$63	$38	$155	$137
Oper. cost/mile @ 60 mph. block	$0 38	$0 38	$0 40	$0 33	$0 50	$0 52	$0 57	$0 97	$1 05	$0 63	$2 60	$2 28
Oper. cost/pass. mile	$0 38	$0 38	$0 40	$0 33	$0 50	$0 173	$0 14	$0 097	$0 096	$0 079	$0 060	$0 057
Oper. cost/ton-mile	$2 71	$2 38	$2 25	$2 19	$1 44	$1 41	$1 90	$0 97	$0 84	$0 77	$0 68	$0 57

[1] Includes hubs and rotor drive. [2] Less hubs. [3] Included in transmission weight.

Fig. 1. Operating costs for 'copters based on ATA formulas. Calculations take into account 25-mi. trip at 60 mph. block speed.

Pinpointing Costs Per Passenger-Mile

By A CANADIAN BUSH PILOT

Precise calculation of this key transport expense is demonstrated, employing the power-space-density method. And as a guide for the operator, the author includes a comprehensive work table, as well as specific computations based on experience figures.

JUDGING FROM RECENT editorials and articles in aviation periodicals dealing with the problems of how to make aircraft pay their way, it would seem that the $64 question still is, "How much does a passenger-mile cost?" The writer has given some thought as to how the answer might be obtained through the use of the power-space density system of aircraft cost analysis.* No fine drawn arguments or references are offered in support of the suggestions offered herewith, since the results must of necessity be easily understood by all who are interested in what a passenger mile should cost.

It is not proposed that there is any one particular cost per passenger-mile that should be accepted as standard throughout the industry. That would not be realistic, since no two air transport companies have the same cost figures, even with similar routes and a similar type of fleet. The price of a passenger-mile as sold to the public, however, is quite another matter, for usually this is fixed by mutual agreement among competitors, or by Government order.

Some uniformity in determining the cost of a passenger-mile can be had, however, by standardizing a large portion of the direct operating expenses in such a way as to reflect the capabilities of the type of aircraft in use. This, then, tends to isolate unknown variables and imponderables to their natural habitats—the payroll, the ground establishment cost, establishment supplies and materials, and various types of financing expenses. Fig-

*"Transport Cost Precision Via P-S-D Approach," page 103, Dec. 1946 AVIATION

WORK TABLE

Basic Data and Equations for Determining Cost per Passenger-Mile

A. Basic Data

1 Cost of aircraft, less power and passenger accommodation
2 Cost of passenger structure and furnishings
3 Cost of one engine
4 Number of engines per aircraft
5. Total cruising power per engine
6. Total payload space (cu. ft.)
7. Cabin space for passengers (cu. ft.), including space occupied by passenger fixtures and facilities, such as cabin heaters, buffets, lounges, etc.
8 Cruising speed of aircraft
9 Seating capacity of aircraft, or average occupancy, whichever is more realistic
10 Free baggage allowance
11 Baggage average density (lb./cu. ft.)
12. Aircraft utilization daily
13 Aircraft life (yr.)
14 Engine life (hr.)
15 Profit (%)
16 Selling price per passenger-mile

B. General Equations

20. Hp.-hr. per aircraft cruise-mile .... [(4) × (5)]/(8)
21. Cu.ft.-miles per aircraft cruise-mile .... (6)
22. Cu.-ft.-miles per hp.-hr. .... (6)/(20)
23. Aircraft life (hr.) .... (12) × (13) × 635
24. Hp.-hr. used .... (23) × (4) × (5)
25. Passenger-miles per aircraft-mile .... (9)
26. Engine life (hp.-hr.) .... (5) × (14)
27. Number of engines required .... (24)/(26)

C. Aircraft Expense

Mechanical Airborne Cost per Horsepower-Hour

30. Depreciation, unfurnished aircraft .... (1)/(24)
31. Depreciation, passenger structure and facilities .... (2)/(24)
32 Overhaul and repair (1), labor .... Your experience figure/hp.-hr.
33 Overhaul and repair (1), material .... Your experience figure/hp.-hr.
34 Aircraft service expense (1), labor .... Your experience figure/hp.-hr.
35 Aircraft service expense (1), material .... Your experience figure/hp.-hr.
36 Aircraft airborne cost/hp.-hr. (1) .... Your calculation
37 Passenger equipment and structure cost/hp.-hr. (2) .... See (31)
38 Passenger installations overhaul .... 40% of (31)

D. Power Expense

Mechanical Airborne Cost per Horsepower-Hour

40. Engine depreciation .... [(27) × (3)]/(24)
41 Fuel per hp.-hr. .... S.F.C. × Price of fuel per lb.
42 Oil per hp.-hr. .... S.O.C. × Price of oil per lb.
43 Engine overhaul, labor .... Your experience figure/hp.-hr.
44 Engine overhaul, material .... Your experience figure/hp.-hr.
45 Mechanical airborne cost/hp.-hr. for power .... Your total

E. Passenger Operating Expenses

Ground Establishment and Personnel, Stewards, Etc.

50 Total of following passenger services accounts .... Your calculation
a. Salaries and wages of station managers, passenger agents, reservation agents, service employees, supervisors, stewards and stewardesses
b Servicing supplies expenses
c Traveling and incidental expenses
d. Office supplies expenses
e. Passenger food service expenses
f. Passenger supplies expenses
g Passenger interrupted flight and travel expenses
h Liability and compensation insurance
i Other expenses
51. Total passenger operating expenses per hp.-hr. .... (50)/(24)

(Table Continued on Next Page)

Traffic Expense

52	Total of following traffic department accounts a. Salaries and wages of supervisors, representatives, and other employees b. Traveling and incidental expenses c. Office supplies expenses d. Telephone, telegraph, and teletype expenses e. Rents of offices f. Agency commissions g. Liability and compensation insurance h. Other expenses	Your calculation
53	Total traffic department expenses per hp.-hr.	(52)/(24)
54	Total passenger operating expenses per hp.-hr.	(51)+(53)

F. Remaining Operating Expenses

Personnel, Materials, Establishment, and Corporation

60.	Total per hp.-hr. expenses for following a. Flight crews b. Administrative personnel c. Executive personnel d. Ground establishment and equipment e. Supplies and materials f. Labor	(60)/(24)
61.	Cost per cu.ft.-mi. to operate aircraft (1)	[(36)+(45)+(60)]/(22)
62.	Cost per cu.ft.-mi. to operate following a. Passenger equipment b. Supporting personnel c. Supplies d. Establishments	[(37)+(38)+(54)]/(22)
63	Cost per passenger-mile	[[(61)×(7)]+[(62)×(7)]] /(9)
64	Price per passenger-mile required	[(63)×(15)]+(63)
65	Support, if any, required from cargo compartment earnings to make passenger business profitable	Difference between (64) and (16)

ues for these expenses vary from one company to another, reflecting to some extent the general operational policies.

In the interest of uniformity it seems necessary to arrange the various company operating expenses under the headings outlined by CAB. Using these headings as a guide, there is a better chance that interpretive errors will be reduced to a minimum. On the assumption that you have available the last annual income and expense statement distributed to accounts in accordance with the CAB list, the cost per passenger mile for your particular company may be ascertained in the manner considered here.

In order to obtain a segregation of capital cost for passenger facilities both built into and installed in the aircraft, it is necessary to make a fairly accurate division of the cost of the aircraft as a cargo type of aircraft without passenger facilities of any kind. The cost of such an aircraft deducted from the cost of the passenger aircraft of the same model, will be the cost of the airborne passenger structure and facilities. These two divisions of the aircraft less power may be treated as your experience dictates, in the matter of depreciation rate and overhaul cost. As usual, the power cost is considered as an expense separate from the aircraft structure.

Cost per hp.-hr. for the direct airborne expense may now be found for the aircraft less power and passenger facilities. In like manner, the cost per hp.-hr. may be found for the passenger facilities that have been installed. For power, the cost per hp.-hr. can also be found, as indicated. This group is designated as mechanical airborne costs.

Next step is to determine, from an inspection of the CAB accounts, what expenses of the passenger service department and of the traffic department are attributed to the business of transporting passengers. These may be totaled and then reduced to a cost rate per hp.-hr. by dividing into the total the number of hp.-hr. used while the expense was incurred.

You will now find that the cost per hp.-hr. has been determined for the following groups of expense:

1. Depreciation and overhaul cost for main aircraft structure.
2. Depreciation and overhaul cost for passenger construction and installations.
3. Depreciation, fuel, oil, and overhaul cost for power.
4. Cost for the operation of the passenger service department and traffic department.
5. All remaining costs, (totaled and divided by the number of hp.-hr. used during period in which they were incurred).

With special reference to the substantial expenses in Group 5, it will be found that, for a given utilization rate, some are bound to be affected by aircraft size.

But others are effected by differences in utilization rate. A further study of the CAB accounts in Group 5 will determine which accounts are influenced primarily by the utilization rate and which by the aircraft size. For the purposes of this study—in which a fixed utilization rate is assumed, or has been accomplished—machine size will be used in terms of total hp.-hr. utilized.

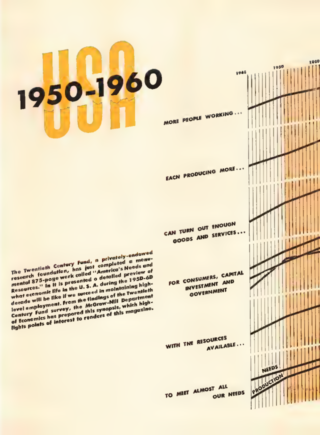
The work table accompanying this article presents basic data and equations for determining your cost per passenger-mile. In addition, a table of sample calculations is included to show how experience figures may be applied on the work table pattern to arrive at costs in the five pertinent expense groups.

SAMPLE CALCULATIONS

Using experience figures derived from operation of a transport fleet composed of aircraft of approximately 1,200 hp., author here applies the rates to operation of an aircraft of 3,600 hp. of cruising. Calculations are for five groups of expenses considered in Work Table.

Items	Expense Groups	Cost Per Hp.-Hr.
(36)	1. Depreciation and overhaul of main aircraft structure	$0.02458
(37) & (38)	2. Depreciation and overhaul cost for passenger accommodation and installations	0.00300
(45)	3. Depreciation, fuel, oil, and overhaul cost for power	0.03144
(54)	4. Cost of operation of passenger service and traffic departments	0.02056
	5. Remaining operating expenses	
(60)	Total per-hp.-hr. expenses for flight crews, administrative personnel, etc. (60)/(24)	0.05800
(61)	0.11402/262.5 = Cost/cu.ft.-mi. of aircraft (1)	0.000435
(62)	0.02355/262.5 = Cost passenger expense net	0.00009
(63)	[(0.000435×3800)+(0.00009×3800)]/40 = (1.65+0.34)/40	0.0495
(64)	0.0495×.10+0.0495	0.05445
(65)	0.05445−0.05100 Amount required from cargo earnings to satisfy demand for 10% profit from a full cabin load*	0.00345

* This final calculation is included to show that, in this case, even fully loaded cabin does not make a profit. Of necessity, profit on operation of all payload carrying capacity must come from load in cargo holds. Obviously, if no mail load is on board at a good rate, operator will have financial worries. If he has 400 cu. ft. of cargo space left for payload, it appears requisite that he use it all to best advantage.



POPULATION

A nation's wealth depends more than anything else on the size and vigor of its population. Much of the increase in U. S. production during the past hundred years is a result of a rapid growth in population. This growth supplied manpower for farms and factories and provided an expanding market for consumer goods and services.

MORE PEOPLE WORKING . .

Growth was the outstanding fact about population before 1930. The birth rate was almost double the death rate and there was a heavy flow of immigrants Between 1900 and 1930, the population increase averaged 15 million each decade Immigration contributed a third of the increase

But this trend was checked by the depression 30's which stemmed the flood of immigrants and cut the birth rate by forcing postponement of many marriages As a result, fewer than 9 million persons were added to the population between 1930 and 1940. This was an important factor in prolonging the depression because it slowed the growth of consumer markets

WARTIME MARRIAGE BOOM

War and postwar conditions have brought a boom in marriages They have exceeded normal by more than 1,500,000 since 1940. There will be more newly-married couples in 1950 than ever before and the birth rate may be roughly 10% higher than in the early 1930's. So the 20th Century Fund looks for an increase of 12 million in total population between 1940 and 1950 and a further increase of 10 million in the 1950's.

This will mean a faster-growing market for homes, autos, food, clothing, and other consumer items than we had in the 1930's. It will mean crowded schools and more people seeking jobs.

There are four major population trends which will affect markets in the 1950's

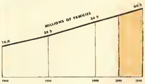
1. The number of families will continue to increase more rapidly than the number of people as families grow smaller This is significant because the market for housing, appliances, and many other things depends more on the number of families than on the number of people.

2. Our population will be getting older. But it will not be getting less productive because the proportion of the population between the ages of 20 and 60 will be higher than in past decades. Still, the most striking increase will take place in the number of people over 60—from 14 million in 1940 to more than 20 million in 1960. This will bring greater demand for medical services and social security. An important cause of this trend is our success in controlling communicable disease. The following table shows how the death rate from selected causes has changed since 1900.

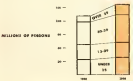
	Death Rate Per 100,000 Persons	
	1942	*1900*
Diseases of heart	295	137
Cancer and other malignant tumors	122	64
Influenza	56	202
Tuberculosis	43	194
Diarrhea and enteritis	9	143
Whooping cough	2	12
Diphtheria	1	40
Measles	1	13
Typhoid and paratyphoid fever	0.5	31
Scarlet fever	0.3	10
Other	505.2	873
	1035 0	1719

TWICE AS MANY PEOPLE

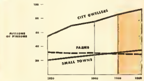
BUT THREE TIMES AS MANY FAMILIES



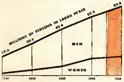
MORE OLDER PEOPLE



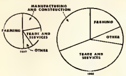
MORE CITY DWELLERS



MORE AND MORE WOMEN ARE SEEKING JOBS



FARMING IS GIVING WAY TO OTHER OCCUPATIONS



3. The population will continue to become more urbanized Small and medium-sized cities will grow faster than the largest cities. The general westward migration which was accelerated by the war will continue.

4. Our people will keep on getting more homogeneous. There has been almost no immigration since 1929, so the number of immigrants who have been in the country for less than 20 years will make up less than one percent of the population in 1950 as against 10% in 1930

An even more important factor in making the population all of a kind has been the growth of universal education. The proportion of children 14-17 years old attending high school doubled between 1920 and 1936 The rise of the radio, movies, and national magazines has also levelled us out These developments not only raise the general educational level of the nation but also tend to standardize the public's tastes and attitudes.

LABOR FORCE

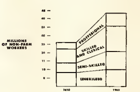
The volume of goods and services produced by 145 million persons in 1950 and 155 million in 1960 will depend on what share of the population is in the labor market and the amount of work those employed actually do. The proportion of the population in the labor force has shown little change in the past few decades So the 20th Century Fund assumes that the relationship between labor force and population will be about the same in 1950 and 1960 as it was just before the war. On this basis 60 million people will be in the labor market in 1950 and 63.4 million ten years later

As you can see from the charts, however, there will be several important changes in the composition of the labor force. More women will be working In 1870 only one out of every eight worked By 1940 the proportion had grown to one out of four, and evidently will go on rising.

However, the increase in the number of women working will just about be offset by earlier retirements and longer schooling. This explains why there is little change in the ratio of labor force to population.

ANATOMY OF THE LABOR FORCE

THE LABOR FORCE IS GROWING MORE SKILLED



UNEMPLOYMENT

The effectiveness of the labor force depends not only on its size but on how fully it is employed We have never had full employment in the sense that everyone able and willing to work had a job at the same time Even in good years unemployment has seldom averaged less than 5% of the working force because workers are always moving from job to job. And in 1932, nearly one-fourth of all workers were unable to find jobs.

For this reason, the 20th Century Fund assumes that, even with good business in the 1950s, unemployment will average 5% of the labor force. This works out to 3 million unemployed in 1950.

In addition, the Fund expects the long down-trend in average weekly hours to continue. A century ago, workers put in a 12 hour day for 6 days a week. By 1940 the average work-week had declined to 44 hours in non-agricultural jobs and 52 hours in agriculture. If this trend continues, the average in non-farm jobs will be down to 38 hours a week in 1960, and farmers will work 48 hours.

Adding all this up, and allowing for vacations, absenteeism, and sickness, the 20th Century Fund estimates that the U. S. will put in 121 billion man-hours of work in 1950 and 118 billion in 1960. This compares with 105 billion in 1940 and with 154 billion at the peak of the war effort The quantity of goods and services that can be turned out with this amount of labor effort will depend on average output per man-hour, or productivity.

PRODUCTIVITY

The key to our future economic welfare is productivity. It is the five-fold increase in output per man-hour that has made it possible for us to work shorter hours and still enjoy a rising standard of living. This increase in productivity has been accomplished not by working harder but by constantly inventing better machinery to supplement human energy with mechanical power.

Of course, in any specific factory at any given time, productivity depends largely on the willingness and ability of labor and management. But over the years, the actual effort of the individual worker becomes much less important than the effort of the machine. The most energetic and skilled blacksmith of a century ago could not remotely approach the productivity of today's semi-skilled worker operating automatic power-driven equipment.

EACH PRODUCING MORE . . .

In 1860, the average worker turned out 33¢ (in 1944 dollars) worth of goods in an hour. By 1940, this had grown to $1.22. This sensational increase in productivity was due to the increased use of power-driven machines. In 1860, the average worker had the help of only half a horsepower of animal or mineral energy. In 1940, he had the use of 2.7 horsepower. To put it another way, if there had been no increase in the use of mechanical power since 1850, it would have taken 290 million workers to turn out the amount of goods and services actually produced at the peak of the war effort by only 63 million workers.

DO MACHINES KILL JOBS

Past history also shows that we need not fear the long run effects of the introduction of labor-saving machines. On the contrary, the only way we can improve the material welfare of everyone is to continue and even step up the rate at which we save labor by using machines.

Some people, it is true, are thrown out of work and a few of them may not be able to find other jobs easily. But mechanization more than compensates for "technological unemployment" by making it possible to produce more and better things for everyone—things that themselves create jobs. Development of the railroads and the automobile, for example, put a lot of canal boat and livery stable operators out of business. But it cut the cost of transportation and created many times more jobs than it eliminated.

The 20th Century Fund also points out that the most important reason that the technological revolution developed luxuriantly in the U. S. between 1850 and 1940 was that competitive enterprise provided a generally favorable climate. It is true that natural resources were plentiful and that the population was growing rapidly both in numbers and in skill. But what we had to a unique degree here was an atmosphere which favored risk-taking, fostered the vast capital investment necessary to harness and apply mechanical energy, and provided the incentives necessary to put capital and inventiveness to work.

No other economy has equalled ours in the ability to produce more and more with continually diminishing human effort. The test it now faces is whether it can eliminate the ups and downs in production and employment that have gone along with it. But an abundance of evidence indicates that we ran into trouble after 1929 not because we developed too many labor-saving machines but because we didn't adjust our economic mechanism to keep the process going.

The key importance of mechanization is indicated by the fact that the increase in national production since 1860 closely parallels the increase in use of mechanical power. Between 1860 and 1940, both volume of production and use of energy multiplied about 11 times. It is clear that, in order to keep our standard of living rising, we must continue to apply more and more power to production.

Chief advantage of mechanical energy is, of course, its low cost. Electric energy is now delivered for as little as a cent a horsepower, while the same amount of human energy costs $10.

And there are other important advantages. Mechanical energy can be delivered in greater concentrations than any other form. It is also more convenient, compact, mobile, and controllable. Consolidated Edison in New York delivers enough electricity in a day to do the work of 3 million draft horses.

These advantages are now so universally accepted that it's hard to realize how recently we left the horse and buggy era. At the turn of the century, animals and men provided more than half the energy used in production and transportation. It wasn't until World War I that trucks replaced horses in local hauling and tractors began to invade the farms. Here is how the use of mechanical energy has grown since 1850.

	Total Energy Output (Billions of Horsepower-Hours)	Percent Supplied by:		
		Mechanical Energy	Humans	Animals
1850	17.6	6	15	79
1860	25.2	7	14	79
1870	27.8	12	15	73
1880	39.9	17	14	69
1890	61.1	28	12	60
1900	82.9	38	10	52
1910	131.4	57	8	35
1920	197.4	73	6	21
1930	238.3	84	5	11
1940	289.4	90	4	6
1950	410.4	94	3	3
1960	489.8	96	2	2

PRODUCTIVITY IN THE FUTURE

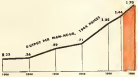
Any attempt to predict future developments in productivity is complicated by the fact that the changes do not occur at an even rate. Between 1850 and 1940 the average increase in output per man-hour was 18% per decade. But the changes varied all the way from 3% between 1870 and 1880 to 42% for the decade ending in 1940. There is, therefore, no simple way to extend past trends to obtain a foolproof figure for productivity at a future date.

For purposes of this study, however, the 20th Century Fund assumes that the average rate of increase since 1850 may be projected to estimate output per man-hour in 1950 and 1960. Thus, output per man-hour works out to $1.44 in 1950 and $1.70 in 1960 as against $1.22 in 1940 (all in 1944 dollars).

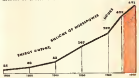
As the Fund points out, this is a critical assumption, and it is further complicated by the fact that there is a wider possibility of error in this estimate than in most of the others in the study. If, for example, it is assumed that productivity will increase at the pace set from 1920 to 1940 which averaged 36% per decade, then 1960 production would be about double the 1940 level instead of only 157% of it, as the 20th Century Fund estimates.

A CENTURY OF ECONOMIC PROGRESS 1860–1960

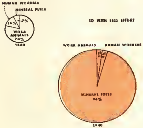
OUTPUT PER MAN-HOUR SHOULD BE 5 TIMES AS GREAT



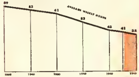
BECAUSE OF A STEADY GROWTH OF POWER AND MACHINES



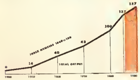
SO WITH LESS EFFORT



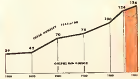
AND A SHORTER WORK WEEK



6 TIMES AS MANY WORKERS CAN PRODUCE 17 TIMES AS MUCH



AND PROVIDE 3½ TIMES AS MUCH OUTPUT FOR EACH PERSON



TOTAL NATIONAL OUTPUT

The potential volume of goods and services in 1950 and 1960 can be determined by simple arithmetic, using the assumptions outlined on the preceding pages. Of an estimated population of 145 million in 1950, about 60 million persons will be in the labor market and 57 million of them will have jobs if we succeed in keeping business activity at a high level.

This many people would work 121 billion man-hours. With output per man-hour estimated at $1.44 (in 1944 dollars) the total value of goods and services produced, or the gross national product, would come to $177 billion. Similar calculations yield a gross national product of $202 billion for 1960.

As the 20th Century Fund emphasizes, these estimates are neither a forecast of actual production nor an appraisal of maximum potential production. They are merely an attempt to show in dollars and cents what can be achieved with high-level employmant.

NIGHER LIVING STANDARDS

Compared with any prewar year, a gross national product of $177 billion in 1950 and $202 billion in 1960 would represent a handsome gain. It would make possible a substantial rise in living standards. In 1950 we would produce a fifth more than in 1941.

CAN TURN OUT ENOUGH GOODS AND SERVICES . . .

However, the volume of goods and services turned out in 1950 would be only slightly higher than present production. This is because the number of persons at work today is 2 million above the estimated normal for 1950, and average weekly hours are higher than they will be than. Almost a million and a half of the emergency workers drawn into the labor force during the war are still at work and unemployment is lower than the figure assumed for 1950.

The estimates of 1950 and 1960 gross national product, as well as the figures for past years used in the chart, are expressed in 1944 prices. This is not a prediction that the price level will settle down to the 1944 level which would involve a drop of 18% in the cost of living and 26% in wholesale prices. It is merely a device to eliminate price fluctuations so that the figures will show only the actual changes in the physical volume of production.

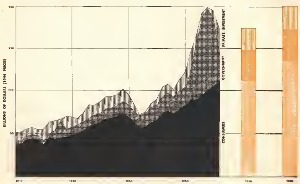
Gross national product measures the total market value of everything the nation produces. All the goods and services produced are absorbed in one of three ways: by consumer expenditures; by expenditures for investment in capital goods or inventories; or by government expenditures.

HIGNER TAXES, LESS INVESTMENT

The division of total output among consumers, investment, and goveroment will be somewhat different in 1950 and 1960 than in the past. About two-thirds of total output will go into consumer goods and services. This is about the same as the proportion in prewar years.

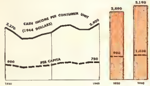
Government's share will continue to grow, however. It rose from 11% of total output in 1929 to 17% in 1940. At the peak of the war effort, half of all production went to Uncle Sam. Government expenditures have dropped to less than half the war peak and they will continue to decline slowly. But government's share will still run to around 20% in the 1950's. On the other hand, the ratio of investment to total output shows a slight long term decline.

HOW TOTAL OUTPUT IS DISTRIBUTED

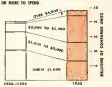


MORE CONSUMER PURCHASING POWER

CONSUMERS WILL BE ABLE TO BUY 50% MORE THAN IN 1930'S



EVERY OTHER FAMILY . . . INSTEAD OF EVERY SIXTH FAMILY . . . WILL HAVE $2,000 OR MORE TO SPEND



CONSUMER INCOME

U. S. business can look forward to a 1950 consumer market twice as large as in the worst year of the depression, half again as large as in 1929, and one-fifth larger than in 1941. That is the major conclusion of the 20th Century Fund's analysis of consumer purchasing power. Here are the steps by which it arrives at that conclusion:

1. With gross national product at $177 billion in 1950, past experience indicates that income payments to individuals would run to $138 billion.

2. Income tax rates are assumed to equal the 1942 schedules, so individuals would pay $11 billion in taxes (as against $19 billion in 1946).

3. Savings are estimated at $12 billion, or about 9% of income after taxes

4. Subtracting taxes and savings, consumer purchases of goods and services would total $116 billion.

LOWER SAVINGS

Many experts would criticize the assumption that savings will amount to only 9% of income. Some of them look for a ratio as high as 20% in prosperous postwar years. The 20th Century Fund justifies the use of a low figure on three grounds: (1) people built up reserve of savings during the war; (2) expanding social security will reduce the need to save for old age, and (3) taxes will cut into savings. The Fund's estimate of savings plus taxes in 1950 adds up to a higher percentage of income than in prosperous prewar years.

The standard of living won't rise as rapidly as the total income going to consumers, because the increased income will be split up among more family units. But the average consumer unit (a family or a single person living alone) will be a third better off in 1960 than in the 1930's.

Shifts in the distribution of income will be even more important, from a marketing standpoint, than the general increase in over-all consumer income. More consumer units will be in the over-$2000 brackets than ever before and this group will be receiving a much larger share of total consumer income.

Part of the apparent increase in income is cancelled out by higher prices. To show the actual increase in purchasing power, the figures should be adjusted for an estimated one-third increase in the 1950 price level over that of the mid-1930's. This would mean that a $2,650 income in 1950 would buy no more than a $2,000 income in 1935-36. Even if this adjustment is made, the resulting figures still show a striking upward shift.

Income Class	Consumer Units in Millions		Cash Income in Billions	
	1935-36	1950	1935-36	1950
Total	39.2	47.9	$85.0	$135.0
Under $1000	20.8	13.0	17.0	7.7
$1000-2000	12.2	12.9	28.1	21.5
$2000-5000	5.5	18.2	23.8	62.1
Over $5000	0.7	3.8	16.1	43.7

FOR CONSUMERS . . .

In addition to dollar income, shown in the above table, consumers also receive "income in kind"—food and fuel produced by farmers for their own use, board and lodging received by domestic servants. Such income will have a value estimated at $3.3 billion in 1950, most of which will supplement the $7.7 billion received by those in the "under $1000" bracket.

The urban market will continue to be far more important than the rural market. Consumer units in cities will receive cash incomes of $3,445 on the average in 1950, more than twice the farm average of $1,635 and almost twice the small town average of $1,880.

THE FARM MARKET

These figures don't provide an accurate measure of the relative importance of the rural and urban markets because rural consumers pay a lot less for food, fuel, shelter and so have more to spend for other things. If there were any way to adjust for these things, the figures would show a smaller spread between the two markets, but the urban market will still be dominant.

All these figures underline a general upgrading in consumer demands which would accompany high-level production and employment. It will have a profound effect on marketing practices. The average person will eat better, dress better, and live in a better house with better equipment. And he will have more money to spend for travel, recreation, and luxuries.

CONSUMER MARKETS

The improvement in living standards during the 1950 decade will lead to important changes in the way consumers spend their dollars. Even though they will eat better, dress better, and live in better houses, a smaller share of the consumer dollar will be spent on food, clothing and shelter. A growing share will go for appliances, furniture, travel, and recreation.

This means that the fastest growing markets will be those providing what might be called "optional" goods and services — things which add to comfort and enjoyment but which are not strictly necessary. Markets for necessities, on the other hand, will expand at a slower rate than total consumer expenditures.

The growing importance of "optional" goods and services is one of the reasons why it's increasingly difficult to keep our economic machine going on an even keel. The purchase of "optional" goods can be postponed with little hardship. So anything that causes people to put off buying a new car, a new house, or a new radio has a far greater effect on production and employment now than it did when the major share of the consumer dollar went for necessities.

Some of the trends in major markets are summarized in the following sections.

FOOD

Although food is by far the largest item in the consumer budget, its relative importance is declining slowly as living standards rise. People eat the same number of pounds of food they ate in 1909 but the food is better from a nutritional standpoint and easier to prepare. Thus, the trend favors fruits, vegetables, and dairy products as against meat, potatoes, and bread.

More and more food is being processed in factories rather than in consumer kitchens. Improved methods of manufacture and distribution have transformed the luxury foods of yesterday into the standard foods of today. New kinds of processed foods — canned, frozen, and dehydrated — are appearing constantly.

STANDARD OF LIVING YARDSTICK: MORE OF THE CONSUMER DOLLAR GOES FOR THE COMFORTS OF MODERN LIFE

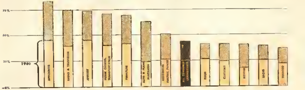
CLOTHING

Three long term trends will shape the clothing market in the future: (1) the shift from home and custom to factory fabrication is almost complete; (2) synthetics, chiefly rayon and nylon so far, are replacing cotton, wool, and silk at an accelerating pace; (3) there's greater standardization of styles and a trend to lighter and simpler clothing.

In 1909 consumers spent 14% of their income for clothing but by 1940 the ratio had reclined to 12%. However, this long run decline may be halted or reversed. The migration from farms to cities, the upgrading of incomes, and the growing demand for sports clothing will increase clothing expenditures.

CONSUMER MARKETS IN 1950 AND 1960: Percent Increase in Sales Over 1940

Bottom Segment Equals Percent Increase 1940-1950; Total Height Equals Percent Increase 1940-1960.

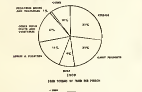


HOUSING

The decline in the relative importance of housing expenditures — from 24% of consumer dollars in 1909 to less than 18% in 1940 — is expected to continue. The reason is that people feel they get more value for their dollars in other things than housing. Nevertheless, the housing market should be much larger in the 1950's than in the 1930's because much of our housing needs to be repaired or replaced.

A Census survey in 1940 showed that 16 million of the nation's 37 million dwelling units needed to be replaced or needed major repairs. The 20th Century Fund estimates that the provision of adequate housing for everyone by 1960 would involve building 20 million new units and rehabilitating 5.4 million at a total cost of $115 billion (1944 prices). The Fund also estimates that we will fall 15% short of this goal even with continued high-level employment.

OUR CHANGING DIET: MORE MILK, FRUITS AND VEGETABLES LESS MEAT, POTATOES AND BREAD



1909

1800 POUNDS OF FOOD PER PERSON

1939

1881 POUNDS OF FOOD PER PERSON

HOUSEHOLD EQUIPMENT

More and more of the consumer dollar has gone for household equipment in the past four decades, largely because of the development of labor-saving appliances. The outlook is for a continuation of this trend. New appliances are being developed, and the large number of new houses slated to be built in the next few years, the wartime and postwar boom in the number of families, and the migration to the cities should add to appliance demand. The same factors should brighten the outlook for furniture, rugs, and other household items.

Some appliance markets may be saturated by the 1950's, however. A few years of high production would fill our homes with refrigerators, for example. However, replacement demand would run to 2.7 million units in 1960 and there would be a demand for 1.3 million refrigerators to equip new houses, so the market would still be bigger than in 1941 when 3.6 million were sold. However, new products must be developed if the industry is to keep up the pace it has set in the past.

TRAVEL

In 1916 the average person traveled 400 miles. By 1940 the average had grown to 2,400 miles, chiefly because of the rise of the automobile. The 20th Century Fund expects this growth to continue because as their incomes rise people spend more money traveling.

A good share of the increased spending will go to purchases of cars and planes. The Fund estimates that there will be 36 million cars on the road and 100,000 private planes in the air in 1950. The auto industry would be able to sell 5 million new cars a year after 1950 — 4 million for replacement and a million for population growth.

WHERE CONSUMER DOLLARS GO

(Figures in Billions of Dollars)

	1909	1919	1929	1940	1941	(1944 Prices) 1950	1960
Total Consumer Expenditures	28.8	60.8	80.3	70.6	80.4	116.2	134.2
Food, Liquor, and Tobacco	9.9	22.3	23.7	21.9	25.3	36.2	41.1
Food	7.4	18.8	19.9	16.4	19.0	27.2	30.8
Liquor and Tobacco	2.5	3.5	3.7	5.5	6.3	9.0	10.3
Clothing and Personal Care	4.4	9.8	12.1	9.8	11.5	16.2	18.7
Housing	6.8	10.1	14.4	12.6	13.3	19.3	21.4
Rent a	5.5	7.9	11.3	9.1	9.7	14.0	15.4
Fuel	1.0	1.5	1.7	1.7	1.8	2.5	2.8
Electricity	0.1	0.3	0.6	0.9	1.0	1.6	1.8
Household Equipment and Operation	2.8	6.2	10.6	8.7	10.3	15.0	17.4
Appliances	0.2	0.4	0.8	1.0	1.3	1.8	2.4
Consumer Transportation	1.6	5.2	8.6	7.3	8.5	12.7	16.4
Autos and Private Planes b	0.6	3.5	6.0	5.7	6.8	9.6	12.7
Local Bus and Street Car	—	—	0.8	0.7	0.8	1.5	1.5
Intercity Bus	—	—	0.1	0.1	0.2	0.2	0.2
Airlines	—	—	c	c	c	0.1	0.5
Railroads	0.4	0.8	0.6	0.3	0.3	0.4	0.3
Medical Care, Insurance, and Death Expenses	1.1	2.8	4.5	4.7	5.2	7.7	8.7
Recreation	0.9	2.1	3.8	3.3	3.7	5.7	6.9
Radio and Television Sets	0.2	0.7	1.0	0.6	0.8	1.1	1.3
Private Education, Religion, and Welfare	1.2	2.2	2.7	2.3	2.4	3.4	3.7

a Includes Estimated Rent for Owner Occupied Homes.

b Includes Original Cost and Operating Expenses

c. Less than $50 Million

CAPITAL INVESTMENT

Investment plays a crucial role in our economy for two reasons. It is by plowing back part of our annual output that we are able to provide better machines and equipment to keep productivity rising. But the amount ploughed back varies widely from year to year. This unevenness of capital investment contributes to the instability of production and employment.

Because capital goods involve the purchase of durable goods, it can be postponed almost indefinitely when the outlook for profits darkens. Thus, capital investment plummeted from $18 billion in 1929 to $5 billion in 1933, a drop of 72%, whereas consumer spending fell only about half as fast in the same period.

MORE FOR EQUIPMENT

There has been an important shift in the relationship between construction and equipment, the two major types of investment. Before World War I, construction made up around three-fourths of total investment but the ratio declined to less than half in 1935-39. Part of the decline is, of course, explained by the fact that the depression left us with ample plant capacity but provided an incentive to buy more efficient machines to cut costs. Nevertheless, there is a well-defined trend towards allocating an increasing proportion of investment to equipment rather than to plant construction.

CAPITAL INVESTMENT . . .

A little less than two-thirds of total investment goes into industrial plants and equipment. Housing and other consumer construction (hospitals, schools, churches) averaged 27% of total investment during the interwar period. Housing fell from a peak of $6 billion in 1926 to $4.7 billion in 1929 and $600 million in 1933; and it had recovered only half the 1926 volume by 1940.

While other types of investment follow the ups and downs in general business, investment in housing construction follows a cycle of its own. This housing cycle is determined by factors such as the vacancy rate, the level of rents, and that of construction costs, which may not follow the trend of general business. When a drop in general business activity takes place during a declining phase of the housing cycle, as it did in 1929, the result is a deep and prolonged depression.

Government investment, of which the largest component is highways, has been much more stable than other types but it doesn't swing enough weight to stabilize total investment.

Because of the wide fluctuations in capital investment, it's much more difficult to estimate future capital expenditures than future consumer purchases. In order to make a relatively stable forecast, the 20th Century Fund bases its estimates on the long term trend since 1879, which shows a slight decline in the share of total output going to capital investment. Thus, investment under conditions of stable prosperity in the 1950 decade is estimated at 16% of total output as compared with a ratio of more than 18% in the late 1920's. On this basis, estimated capital expenditures work out to $28 billion for 1950 and $33 billion in 1960. Our ability to maintain high employment and rising living standards will depend in large measure on our ability to invest that much profitably in new machinery and buildings.

CAPITAL NEEDS

Analysis of our capital needs lends little support to the idea prevalent during the 1930's that we had reached economic maturity so that there was no way to invest as much as we had in earlier decades. No one has ever made an estimate of how much it would cost to modernize our industrial plant, which is valued at around $200 billion at prewar prices. If as much as a third of it needs to be replaced or rehabilitated, around $100 billion (current prices) of additional investment will be required.

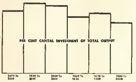
In addition, huge amounts of money need to be invested in housing and public works to raise the services provided merely to adequate levels. The 20th Century Fund estimates that the cost of a 15 year program to modernize our city streets and rural highways would run to $40 billion. To bring the nation's housing up to minimum standards of health and decency by 1960 would cost $115 billion. To conserve our natural resources and develop our water power would cost $27 billion over a 15 year period.

There seems to be little question that needs exist for all the capital investment we can make for a long time to come. The behavior of investment in the past strongly suggests that the problem is not one of lack of needs but one of finding ways to add to our capital in an orderly fashion. Capital investment has followed the boom and bust route in the past; what is wanted is a high but steady rate of investment.

WHERE INVESTMENT DOLLARS GO
(Figures in Millions of Dollars)

	(Annual Averages) 1920-1924	1925-1929	1930-1934	1935-1939	1940-1944	(1944 Prices) 1950	1960
Total Capital Investment	$12,428	$17,186	$8,215	$10,445	$12,340	$27,700	$33,000
All Industries	7,570	10,112	5,272	6,889	8,089	17,800	21,125
Manufacturing	1,996	2,362	1,074	1,610	3,731	4,200	5,025
Food	261	357	194	244		228	273
Textiles	227	212	92	117		175	210
Steel	138	188	110	192		853	1,021
Autos	105	150	78	146		369	441
Chemicals & Petroleum	70	95	68	142		928	1,111
Machinery	—	—	—	28		180	216
Other	510	625	213	409		1,462	1,750
Transportation	1,797	2,303	1,277	1,822	805	4,300	5,100
Commercial	1,196	1,940	777	719	833	1,950	2,300
Utility	693	999	483	422	780	1,500	1,625
Other	1,888	2,508	1,661	2,316	1,940	3,950	4,700
Consumer Construction	3,806	5,557	1,547	2,256	2,912	7,200	8,255
Government Construction	1,052	1,517	1,396	1,299	1,338	2,700	3,620

OVER THE YEARS ABOUT 1/5 OF TOTAL OUTPUT IS PLOWED BACK AS INVESTMENT



BUT THE AMOUNT PLOUGHED BACK VARIES GREATLY FROM GOOD YEARS TO BAD, ACCENTUATING THE SWINGS OF THE BUSINESS CYCLE

WARTIME INVESTMENT DEFICIT

Demand for capital goods is stronger right now than ever before, largely because of the backed-up needs arising out of the war. Here is how wartime expenditures for capital goods which can be used in peacetime production compared with expenditures in the last 5 years of both the 1920's and 1930's: (Figures in billions of dollars)

	1925-1929	1935-1939*	1940-1944
Total Capital investment	$86	$65	$49
Industrial	51	43	32
Manufacturing	12	10	14
Metals, chemicals, machinery, petroleum	6	6	11
All Other	6	4	3
Commercial	10	5	3
Railroads	5	3	3
Electric power	5	3	3
Consumer Construction	28	14	12
Public Works	7	8	5

* Adjusted to Wartime Prices

Wartime restrictions held investment in all civilian lines far below what would be spent in prosperous peacetime years. Thus, there was a backlog of investment needs at the end of the war which ran to more than $30 billion, if the 1925-1929 demand can be taken as typical. Whatever the precise size of the backlog, it is clearly great enough, when added to the normal yearly demand for new investment, to keep the heavy goods boom going for some time to come. The test of our ability to stabilize capital investment will come later.

There is also a huge foreign demand for American capital. How far we will go toward meeting this depends largely on whether international political and economic conditions are stable enough to make private foreign investment a good risk.

If we invest abroad in the same proportion we did in the late 1920's, our foreign investments will total $1.6 billion during the year 1950 and $1.5 billion in the year 1960. This will mean a net increase in our foreign holdings of $15 billion during the 1950's, raising the total of such holdings to about $25 billion, as against a total of $10.6 billion in 1940.

To make that much foreign investment pay out, an expanding volume of world trade would be required. Foreign nations would have to get enough dollars not only to pay for goods they bought from us but also to pay interest and dividends on U. S. investments. If our overseas investments increase to $25 billion by 1960, annual interest and dividends owed us will run to almost $1¾ billion.

To pay us that much, foreign nations would have to sell much more in the U. S. than ever before. The 20th Century Fund calculates that imports of $7.3 billion in 1950 and $8.1 billion in 1960 would provide other countries with the dollars they need. Imports ran to $2.5 billion in 1940 so we would have to buy 3 times as much abroad to keep expanding our foreign investments.

With good business, U. S. demand for imported goods should be well above prewar. Rising living standards will widen the market for such consumer items as British tweeds and French perfumes. Moreover, we will need to import more raw materials than ever before because we used up our natural resources at a prodigious pace during the war.

NEW INDUSTRIES

The new methods, materials, and products developed during the war may well have a more profound and lasting effect on future capital requirements than the backed-up demands accumulated in wartime. Here are some of the wartime developments which may have important peacetime applications: new chemical processes and products including synthetic rubber, plastics, synthetic fibers and fabrics, new food products and new methods of food processing; new uses for glass, plywood, and the light metals; tremendous advances in aviation; and new applications of atomic energy and fissionable products in power production and medicine.

Large capital expenditures will be required to push these developments further and adapt them to civilian use. New businesses and perhaps entire new industries will grow up, adding to the demand for capital goods for many years.

THE COST OF GOVERNMENT

To the traditional certainty of death and taxes can be added the certainty that the cost of government will take a much larger share of national income than ever before in peacetime. After the Civil War and again after World War I, federal expenditures moved up to a level four times prewar. And it is already clear that World War II is going to have about the same effect.

In 1940, federal, state, and local governments spent $19 billion, of which a total of $2.2 billion went for national defense, veterans, and interest on the war debt. By 1950, the 20th Century Fund estimates that all governmental units in the U. S. will be spending more than $45 billion. Federal expenditures are estimated at $27.6 billion in that year as against $9 billion in 1940.

Part of the increase is explained by higher postwar prices. Adjusting for price changes would reduce the 1950 figure from $45 billion to $33.5 billion. This is still 80% above the 1940 level. Increased expenditures for public works, social insurance, and schools explain another small part of the rise.

But costs arising out of the war are by far the most important factor. Military and veterans' expenditures and interest on the war-swollen national debt will add up to over $17 billion in 1950. This is only 10% less than total government expenditures in 1940.

The only major category of government expense which would be lower in 1950 is welfare. With high-level employment and more social insurance, relief and other welfare costs should run to $2.5 billion in 1950 as against $3 billion in 1941.

The following paragraphs describe important trends in the major items of government expense.

MILITARY

The 20th Century Fund assumes that we will maintain an armed strength of 2 million men (including trainees) and that it will cost $3,300 to equip and maintain each man, so total military expenditures will run to $6.6 billion. But even if we decide to maintain a smaller armed strength, the total cost might easily be at least $6.6 billion because the present per serviceman cost of over $6,000 a year may not decline.

AND

GOVERNMENT . . .

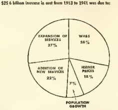
VETERANS

It will cost at least $2.9 billion to take care of veterans in 1950 even if benefits are not increased. That's 5 times the 1941 cost. Pensions for World War I veterans rose steadily from $116 million in 1924 to over $300 million in 1945. That rise will continue for another 20 years. By far the largest expense will be for World War II pensions which are already costing $900 million. Disability and death benefits will cost about $1¾ billion in 1950; hospitalization will add another $250 million; and insurance $150 million.

SOCIAL SECURITY

Future expenditures for social security will depend on whether steps are taken to extend coverage and liberalize benefits. Over 60 million people are now covered so the cost is certain to increase rapidly as more of them begin to draw payments. With high-level employment in 1950, estimated old age and unemployment benefits under the present system would run to over $5 billion. Expansion of benefits, as recommended by the Social Security Board, would raise the cost to over $9 billion.

WHY THE COST OF GOVERNMENT HAS INCREASED. The $25.6 billion increase in cost from 1913 to 1941 was due to:



PUBLIC WORKS

Even an economy-minded Congress is almost certain to go along with expenditures for highways, airports, waterways, flood control and conservation. Thus, an increase in expenditures for transportation and natural resources from less than $2.5 billion to over $5 billion in 1950 seems probable.

SCHOOLS

Education ranks third among all government expenditures. In 1941 we spent almost $2.5 billion—10% of all government dollars—on schools. Teachers' salaries account for almost three-quarters of the total cost so the trend towards higher salaries will boost the nation's bill for education.

WHERE TAX DOLLARS GO
(Figures in Billions of Dollars)

	1913	1932	1941	1950 (1944 Prices)	1960 (1944 Prices)
All Government Expenditures	2.5	12.4	23.1	45.5	50.7
Federal	0.7	4.3	12.9	27.6	28.6
State	0.2	1.8	3.6	7.0	9.3
Local	1.6	6.3	6.6	10.9	12.8
Military	0.27	0.7	6.1	6.6	6.6
Veterans	0.18	0.8	0.6	2.9	3.2
Interest	0.15	1.3	1.7	7.8	8.1
Social Insurance	–	0.2	1.9	7.7	8.7
Welfare & Health	0.31	1.5	4.1	4.0	4.1
Education	0.65	2.5	2.7	3.7	4.3
Public Works	a	a	a	5.6	7.1
Transportation	0.40	1.8	2.0	1.8	2.7
Natural Resources	0.03	0.6	1.4	1.2	1.1
Police & Fire	0.16	0.7	0.7	1.0	1.1
Other	0.40	2.4	2.0	3.0	3.6

a Included in other groups.

NATURAL RESOURCES

The war left the U. S. with a depleted supply of most natural resources, and with critical shortages of some of the most essential minerals. Nevertheless, lack of natural resources should not be a limiting factor on our productive capacity. With relatively free access to world markets, we should be able to get all the raw materials we need. And, even if we were denied access to world markets, we could use our low-grade reserves and develop substitutes without causing a prohibitive reduction in our living standards, though everyone would feel the effects in one way or another.

The U. S. economy consumes about a billion and a half tons of raw materials each year, or about 11.5 tons per person. Of this 3.5 tons are coal, 1.5 tons are petroleum, and iron and copper ore each contribute about a half a ton. In 1939 the value of unrefined minerals output was $4.2 billion and 2% of all workers were engaged in mining or lumbering.

FUTURE REQUIREMENTS

The level of industrial production projected by the 20th Century Fund would raise minerals requirements a third above 1940 by the year 1950 and 50% above 1940 a decade later. Here is how natural resources requirements in the 1950 decade would compare with 1940 and the wartime peak: (Index numbers, 1940 equals 100)

	Wartime Peak	*1950*	*1960*
All minerals	138	133	151
Metals	157	117	126
Fuels	130	141	164
Other	141	128	142
Lumber	126	93	76
Electric Power	159	173	224
Manufactured Gas	120	94	75

The capacity of our supplies of natural resources to support future levels of output cannot be determined with any great accuracy. It will depend on the size of our reserves and on our ability to use supplies more economically and develop substitutes.

WITH THE

RESOURCES

AVAILABLE . . .

Because there is no way to measure these factors with any degree of precision, all estimates of the number of year's supply are subject to wide errors. However, such estimates are useful in directing attention at those resources where every effort should be exerted to develop new supplies, substitutes, and more economical methods of use.

BIGGEST PROBLEMS: LEAD AND ZINC

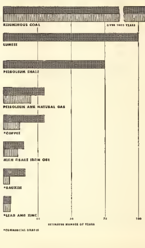
Commercial grades of zinc, lead, and bauxite will be exhausted before 1960 even if the rate of use is cut to half the wartime rate. Supplies of petroleum and natural gas—which furnish 40% of our energy—will last longer than 20 years but their partial depletion will raise many technical and economic problems long before that time. Possible exhaustion of high-grade deposits of such minerals as iron and copper in the foreseeable future will stimulate development of processes to use low-grade deposits.

We have been discovering more and more ways to stretch our supplies of natural resources, however. In the case of tin, the electroplating process saves 50% of the tin used in tinplate production. The electric power industry uses less than 40% as much coal per kwb now as in 1920. The development of new materials and new ways of using old materials also expands our resource capacity.

Our bituminous coal reserves are adequate for over a thousand years even at the wartime rate of use, though production costs might rise substantially as inferior coal beds were used. After that, there are huge deposits of sub-bituminous coal and lignite which could carry us along for another thousand years. In comparison, maximum petroleum reserves are minute, adequate only for about 30 years consumption at the current rate. That is why the experts are trying to find ways to produce oil from coal cheaply enough to be commercially feasible.

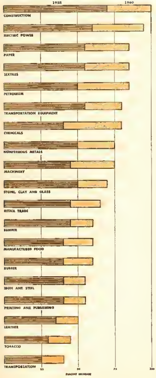
Even though we have been using up lumber faster than it grows, there is little doubt that enough will be available in the future to meet at least minimum needs. Annual timber growth runs to about 32 billion board feet. But we cut over 40 billion board feet a year before the war and lost another 6 billion through fire, insects, and disease. An adequate conservation program could increase annual growth enough to offset this depletion.

OUR NATURAL RESOURCE RESERVES
Years required to exhaust supplies



*COMMERCIAL GRADES

PRODUCTION PROSPECTS: Estimated Percentage Increase in Industrial Activity Over 1940



INDUSTRIAL CAPACITY

At the end of World War II U. S. industry found itself with surplus capacity in some lines and serious deficiencies in others. There was more than enough aircraft, machine tool, and synthetic rubber capacity but not nearly enough sheet steel, copper, or electrical machinery capacity to meet pent-up demands.

War experience showed, however, that industrial capacity can be expanded enormously in a few years, given the need and the funds. Thus lack of industrial capacity should not prove a bottleneck to meeting the demands of consumers in the 1950 decade.

A rough estimate places our total investment in industrial facilities (manufacturing, mining, transportation, and distribution) at $200 billion. Just how much capacity industry as a whole, or any given industry, has is impossible to measure.

Capacity is a most elusive concept. In a technical sense, the capacity of an industry is the combined production of all its plants working 24 hours a day, 365 days a year, less an allowance for repairs, breakdowns, and other technical factors. Actual capacity is far less, however. Some facilities are obsolete or high-cost. Supplies of raw materials and components may be insufficient to keep assembly plants running full-steam. Moreover, demand for many products isn't great enough to support round-the-clock production.

PLENTY OF CAPACITY

During the past quarter century, however, experience shows that we have had more than enough overall capacity, and more than enough capacity in almost every industry, to meet all demands. An extensive study showed that even in 1929 only the steel and machine tool industries were definitely operating at capacity.

The growth of productivity as old machines are replaced with new and more efficient ones and as new techniques are developed is one of the main reasons why industrial capacity more than keeps pace with markets. The depression of the 1930's led to a net retirement of about 5% of total manufacturing facilities but manufacturing plants in 1939 could have turned out a quarter more than in 1929 because productivity was a third higher.

Whenever an industry's output begins to approach technical capacity, it becomes profitable to purchase new and more efficient equipment to replace or supplement existing machines so that a certain amount of excess capacity seems to be inevitable in a free enterprise system.

Estimates of the level of industrial production in different lines under conditions of high-level employment during the 1950 decade are shown in the chart. They assume that past trends will continue so that they give only a rough idea of what would happen to output in each industry. Unpredictable shifts of consumer demand or new product developments might cause a big change in the pattern of industrial production. Such estimates are, nevertheless, useful in that they provide a clue to lines where the largest increases may take place.

None of the projected increases are so large as to tax our ability to provide enough capacity. This is not to say that there will be no bottlenecks because of lack of capacity for certain components, for instance. However, we should be able to make good in short order any deficiencies of that sort that may develop.

DEMANDS VERSUS NEEDS

Despite the substantial increase in living standards which would be possible with high-level production and employment in the 1950 decade, many U. S. consumers will be unable to buy enough of life's necessities to maintain themselves at a health and decency level. Almost 30% of all families would receive less than $1,000 a year cash income and one-third of this group would receive less than $500.

The 20th Century Fund asked a series of experts to estimate the quantities of food, clothing, housing, medical care, and other things needed to provide a standard of living at a minimum health and decency level. The experts also figured out how much it would cost to bring everyone expected to be below that standard in 1950 and 1960 up to the calculated level. In other words, the estimates show the cost of establishing a "floor" for consumption without disturbing the spending patterns of those who received more than enough income to satisfy the calculated minimum needs.

ESTIMATES OF NEEDS

Any estimate of "needs" must rest upon someone's opinion as to what constitutes "health and decency" in this day and age. In the case of food, the nutritional requirements of a minimum health and decency standard can be determined accurately. In other fields, such as housing and education, even the experts would disagree over what constitutes a minimum standard.

However, what is important is not the precise size of the estimates but their general magnitudes. The conclusion that we would have to spend about 50% more on medical care than we are likely to in 1950 is important even if the experts' appraisals of the deficit range from as high as 60% to as low as 40%.

To fill total needs calculated in this manner would require production of $200 billion of goods and services in 1950 or 13% more than the $177 billion which would be turned out with high-level production and employment. In 1960, estimated production would fall short of needs by 8%. Food accounts for the biggest share of the deficit but needs outrun demand by important margins in housing, medical care, education, and social security.

TO MEET ALMOST ALL OUR NEEDS

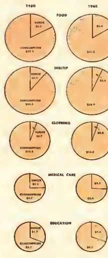
To provide nutritionally adequate moderate-cost meals for those unable to afford them would add $5.5 billion to the $27.2 billion that would actually be spent on food in 1950. This assumes no change in diets of those with adequate incomes despite the fact that many people in those groups do not eat what they should. If we all ate what we needed, we would consume twice as many fresh vegetables as in 1940, half again as much milk, more fruits and tomatoes; and we would eat smaller quantities of sugar, sirups, fats, and oils. This better diet would cost us less than we will actually spend for food in 1950.

So large a portion of our existing housing is unsatisfactory by any reasonable standards that it would take 10-15 years to provide everyone with adequate housing. One of the reasons why we don't have adequate housing is that many consumers cannot afford to pay enough rent to finance it. Estimated expenditures in 1950 for rent (including the estimated rental value of owner-occupied homes) would run to $14 billion as against an estimated need of $16.4 billion.

Vast advances in medicine have gone far toward eliminating many diseases and have brought about a steady improvement in the standard of health. However, large numbers of people in the lower income groups cannot afford adequate medical care. Moreover, to supply good medical care for everyone under the traditional fee-for-service basis would cost several times more than consumers have ever spent for medical services even in prosperous years. Development of an effective form of group medicine, however, would make it possible to provide adequate care at a great saving over present costs, according to the 20th Century Fund.

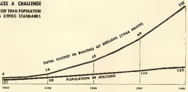
HOW CONSUMPTION WOULD COMPARE WITH TOTAL NEEDS

(Figures in billions of dollars)



THE U. S. ECONOMY FACES A CHALLENGE

PRODUCTION HAS GROWN FASTER THAN POPULATION GIVING PROMISE OF RISING LIVING STANDARDS



The major conclusion of the 20th Century Fund's survey of America's needs and resources is that we have reached a point where we can provide everyone with a decent living and most people with a living which, by any standards other than our own, is positively luxurious. With high-level employment, it would take only a 13% increase in total output in 1950, and an 8% increase in 1960, to lift everyone to a minimum health and decency standard of living.

We have more than enough industrial and agricultural capacity to support that much of an increase in total production. Lack of natural resources should not be a bottleneck, for with world trade on any sort of a reasonable basis we will be able to get all the raw materials we need.

The only limiting factor is the capacity of our labor force to produce. The 20th Century Fund assumes that productivity will advance at the average rate actually achieved during the past 9 decades (18%). But there is no technical reason why we cannot achieve an increase of more than 30%. That would make possible enough production to meet our minimum needs.

The U. S. economy has exhibited two dominant characteristics in the past century. Our productive capacity has expanded at a rate never approached elsewhere. But our economy has also been highly unstable. Our problem is to make the most of our unparalleled technological and productive know-how while minimizing the swings of the business cycle.

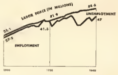
If we can meet that challenge, we can eliminate the specter of want and move on toward constantly rising living standards for everyone. Never before in history has a nation been so close to abolishing poverty and meeting the material demands of its citizens.

This is not to say that solving the problem of maintaining stable and expanding production would solve all our economic, social, and political problems. Nor is it to say that a solution of the problem of keeping our economic machine running on an even keel is at hand.

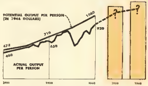
In the first place, the U. S. would not be a utopia even if we achieved the kind of high employment and production the 20th Century Fund is talking about. Many perplexing problems of how to best distribute our production would remain. Then there are a host of social and political problems which would still tax our efforts and ingenuity. Finally, there is the all-important question of how to maintain world peace.

Most people would agree that the problem of maintaining high employment and rising living standards is still far from solution. Our ability to mobilize and direct our economic resources so as to keep our

BUT THE GROWTH HAS FOLLOWED THE BOOM AND BUST ROUTE INVOLVING LONG PERIODS OF MASS UNEMPLOYMENT



CAN THE ECONOMY PROVIDE STEADY EMPLOYMENT AND RISING LIVING STANDARDS?



economy running on an even keel has lagged behind our ability to solve technical production problems. Each businessman, each worker, and each consumer must somehow learn to act differently in many ways than he has in the past if we are to solve our number one economic problem.

Just what changes in our economic life will be necessary no one knows. On our ability to find out these things and put them into practice in the next few years depends our success in meeting the challenge which the 20th Century Fund's study underlines. That challenge is that we have within our grasp the ability to eliminate actual want from the U. S. and to provide more and more things for better living for everyone.

Reprints of this report are available at a charge of 25¢ each to cover the cost of handling and mailing. Address orders to Department of Economics, McGraw-Hill Publishing Co., Inc., 330 West 42nd Street, New York 18, N. Y.

Recent Books

INTRODUCTION TO AERODYNAMICS OF A COMPRESSIBLE FLUID, by Hans W. Liepmann and Allen E. Puckett, John Wiley & Sons, Inc., New York City 262 pages $4.00

Probably the first introductory book on compressible fluids to be published in English, this work should be of real value to aero engineers and physicists working in field mechanics also to advanced students of elementary fluid dynamics. Part I of this volume "One Dimensional Motion" concerns basic compressibility phenomena under conditions entailing relatively little mathematics, and Part II, "Two and Three Dimensional Geometrical Dimensional Motion," treats more difficult phases and includes the mathematics which are requisite in the various computations.

PLASTIC MOLDS, by Gordon B. Thayer Hoehner Publishing Co Cleveland, Ohio Illustrated, 246 pages $3.00

In this third edition the author, plastics research engineer with the Dow Chemical Co., has doubled the size of his second edition published in 1944. A chapter on estimating plastic molds has been included, and a more comprehensive treatment of the nomenclature of plastic moldings has been added. With new plastic applications coming in at rates even faster than during the war, students and engineers alike will find this volume a valuable guide in design and construction.

RADIOGRAPHY IN MODERN INDUSTRY, Eastman Kodak Co X-Ray Div., Rochester, N. Y. Illustrated $3.00

This volume represents the work of a number of people in Kodak's research laboratories and industrial X-ray division, augmented by reports of the company's field representatives on radiographic techniques. It is a complete and authoritative treatment of the employment of radiography techniques in industry, extending from basic operation to final assembly. Engineers, production men, and inspectors will find this comprehensive consideration of the subjects of particular value.

THE AVIATION ANNUAL OF 1947, Edited by Reginald M. Cleveland, Harper & Bros. New York City 230 pages Illustrated. $5.00

Complete in one volume a thorough chronological coverage of aviation's progress in transport, military and private flying is here provided for the reader. Leading figures in each field treated contribute their special knowledge. Included are the military, NACA, Aircraft Industries Assn, Personal Aircraft Council, and Air Transport Assn. Preceding various sections are forewords written by key aviation personalities. Many fine pictures heretofore unpublished will be found in the book. 64 pages of the year's best aviation photos.

ROCKETS AND SPACE TRAVEL—THE FUTURE OF FLIGHT BEYOND THE STRATOSPHERE, by Willy Ley, Viking Press, New York City. Illustrated. 374 pages. $3.75

This is a revised and enlarged edition of the author's earlier work *Rockets* (1944). Supplemented with much new material, the book includes detailed accounts of the experiments of Dr Robert H Goddard, pioneer rocketeer, and of the work of Count Wernher von Braun, father of the V-2 projectile.

THE AMERICAN INDIVIDUAL ENTERPRISE SYSTEM. Its Nature, Evolution and Future, by The Economic Principles Commission of the National Assn. of Manufacturers. McGraw-Hill Book Co., New York City. Vol. 1 and 2. 1119 pages combined. Two volumes boxed, $10.00

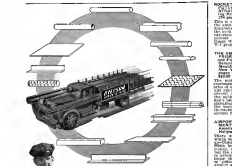
The matter discussed in both volumes represents the collective thoughts and theories of a group of outstanding economists and executives as well as the findings in several independent research studies on the subjects covered. In response to today's need for a realistic and factual explanation of America's economic system, the various contributors clearly and authoritatively describe exactly how the system functions.

AIRPORT OPERATION AND MANAGEMENT, by Charles A. Zweng, Pan American Navigation Service, North Hollywood, Cal. Illustrated. 312 pages.

There are three principal groups from which most airport managers have come: 1—Commercial pilots, 2—men with a frank business interest only in making money, and 3—political appointees with but the slightest knowledge or no interest in aviation. This book does not mean to imply that pilots, general businessmen, or politicians cannot become successful airport managers: they can if they combine these accomplishments with requisite training. Mr Zweng's covers his subject with complete frankness on every phase—from starting on a shoestring to managerial and operational procedures required on a Class 5 port.

Special Publications

The State Dept., through the Government Printing Office, has just issued its first report of the United Nations Atomic Energy Commission to the Security Council. Findings and recommendations cover the basic principles which Bernard Baruch first offered and consistently advocated throughout the negotiations. Price of report is 25¢, from Supt. of Documents. The Air Power Club of Paterson, N. J., is sponsoring a lively little publication titled "Aviation in New Jersey", first edition of which recently appeared. Featured are articles of interest to both residents and non-residents of state. Subscription is $2.00 and per-copy price 25¢. "Aae Study of the Flying Public" is a 10-page booklet issued by the CAA revealing a number of facts about both those who do and do not fly. Basic information comes from 15,000 medical records of 10,000 pilots. In substance many young Americans who have little money take up flying, but when they get older and earn more, they tend to quit piloting. "Facts For Industry" newly issued by the Census Bureau, includes pertinent data and statistics on aviation such as aircraft shipments.



Aviation People

Sherman M. Fairchild (photo) has formed his own consulting organization—Sherman Fairchild & Associates

S. M. Fairchild

George P. Wylly

—to evaluate businesses, products, and ideas and undertake technical and research projects.

George P. Wylly (photo) has been appointed treasurer of Scandanavian Airlines System, Inc. For past 4 yr he has been chief auditor of Republic Aviation Corp and prior to that was chief project auditor with construction division of Army Quartermaster Corps. (Bachrach photo)

Allen W. Jacobson (photo) has been named factory general superintendent for Boeing Aircraft Co. He was former

A. W. Jacobson

P. M. Wilcox

manager of company's experimental shops, in which capacity he supervised work on Boeing's XB-47 jet bomber and other experimental projects.

Philip M. Wilcox (photo), formerly v-p in charge of administration for TACA Airways, has been elected v-p of Charles A. Rheinstrom, Inc., aviation consulting company. (Bachrach photo)

Paul Hovgard (photo) has been named general manager of Piasecki Helicopter Corp. Veteran of more than

Paul Hovgard

James C. Scott

20 yr in aviation, he was previously in rotary wing field from 1932 to 1936. Prior to joining Piasecki he was associate director of Cornell Aero Lab. **James C. Scott** (photo) meanwhile has been made Piasecki factory manager. He is now working on production of the Navy HRP-1 transport and experimental development of XHJP-1 utility helicopter for Navy and XR-16 for AAF.

Burdette Wright, v-p of Curtiss-Wright has been elected chairman of Eastern region public relations advisory committee of AIA, and **Allen W. Betts** has been appointed secty of industrial preparedness committee of AIA.

Walter V. Trelease has been appointed mfg representative in charge of sales and product development of All American Aviation, and **Lambert R. Pistoles** has been named product engineer.

Robert R. Schull has been appointed public relations representative in N. Y. for North American Aviation.

Arthur W. McGrath has been appointed operations mgr in U S for Linea Aeropostal Venezolana.

William M. Ambrose has been named Latin American representative of the Frank Ambrose Aviation Co.

Jennings Randolph is now asst to pres. of Capital Airlines and **Walter E.**

Stewart has been named interline and agency representative for Capital.

Luis de Florez has been appointed a director of National Aviation Corp.

Don R. Berlin has been elected a v.-p. of McDonnell Aircraft.

Carroll J. Peirce, Jr., chief of aerodynamics for Boeing at Wichita, has been named director of Ohio State University School of Aviation.

Ted T. Hanna has been named asst. to pres. of Southwest Airways, and **Thomas R. Foster** is now gen. mgr. of parts dept.

Lt. Gen. Ira C. Eaker, deputy AAF commander, has applied for retirement effective June 15.

Donald A. Huff has been selected as director of express and cargo for Peruvian International Airways.

John Airey has been elected pres. of Automotive & Aviation Parts Mfg. Inc. for '47.

Robert W. Lea, pres. of Johns-Manville, is now a member of board of directors of Curtiss-Wright.

Following have been elected directors of Luscombe: **James P. Cunningham, Comdr. J. D. Hedda p, Capt. Garland Fulton, L. H. Rietz, John A. Pace, Robert Perrot, and William C. Seurry.**

Following officers have been elected to aviation advisory committee of American Petroleum Institute: **Aubrey Keif**, chairman; **L. A. Henry**, vice-chairman; and **A. T. Hapke**, sec'ty.

H. S. Darr has acquired control of Monarch Air Lines, Denver, and will act as president.

Col. Leonard F. Harman has been named Dayton representative for Northrop.

Ray Proctor has been appointed engr. in charge of landing gear div. at Menasco.

Lt. Col. William M. Matthews has joined Luttrell & Senior, aviation consultants.

Beech appointments: **Lee H. Smith** has been named sales mgr., and **Phil McKnight** has been made public relations director.

Frederick V. H. Judd has been awarded SAE Wright Brothers Medal for '46 for his paper on cowl design.

James Stalnaker has been appointed sales engineer in charge of Eastern office of Ryan's metal products div.

Richard Goodspeed has been appointed gen. traffic mgr. for Philippine Air Lines.

Following have been named to Non-Scheduled Flying Advisory Comm. of CAA: **Oliver Parks**, head of Parks Air College; **Leslie Marsden**, air service operator; **William L. Anderson**, exec. director of Pennsylvania Aero Commission; **Dick Depew**, private flyer; **John W. Friedlander**, pres. of Aeronca;

George Haddaway, editor of "Southern Flight"; and **Dan Flower** of Cessna.

B W. de Guichard has been elected pres. of Airquipment Co.

Leo A. Carter has been appointed Santa Monica plant mgr for Douglas

S E Eades, Douglas traffic mgr., has been elected gen. chairman of AIA's western regional traffic committee.

H. A Taylor has been appointed exec. in charge of all public relations for Airspeed Ltd

Lt. Gen. Barney McK. Giles has been elected a v-p of Air Associates.

Maj. Gen. Arthur R Wilson has resigned as v-p and European director of TWA

Herman Van Fleet, Jr. has been appointed mgr of AIRCO's New England district.

Robert W. Russell has been named administrative asst of Hamilton Standard Propellers div. of United Aircraft.

H. Kenn Trenary has joined Goble Aircraft Specialties as asst to pres.

New Construction

AIRPORTS & AIRBASES

PROPOSED WORK

Danbury, Conn.—AIRPORT—City, C. L. Sweeney, municipal airport, incl. new land for expansion, land work, grading Building taxiways, runways, etc. $198,000 80,000 bonds voted.

Panama City, Fla.—AIRPORT—Panama City Airport Auth., plans 60% completed, modern airport. $200,000 Smith & Gillespie Roberts Bldg., Jacksonville, consult. engrs.

Salina, Kas.—AIRPORT—City, $203,000, bond election airport. $400,000.

St. Cloud, Minn.—AIRPORT—City, A. J. Haberkorn, clk. municipal airport imprvs, incl. grading, fencing, 3 landing strips, and wiring alterations, $100,000 $25,000 bond issue approved. Magney, Tusler & Setter, 202 Foshay Tower, Minneapolis, consult. engrs.

Fayetteville, N. C.—AIRPORT—City voted $128,000 bonds, airport $210,624 Wm. C Olsen, 6 Exchange Pl., Raleigh, consult. engr

Tahlequah, Okla—AIRPORT—City, airport landing strips, admin. bldg. and hangar $101,000.

Bedford, Pa.—AIRPORT—Joint committee of Everett and Bedford airport and admin. bldg., hangars runways, one 300x3,000 ft., one 170x3,000 ft. $275,000 Gee Hitchcock 25 E. Main St., Everett, consult. engr

Anchorage Alaska—AIRPORT—City, City Hall, voted bonds, airport, with two 000x8,000 ft. hardsurfaced runways, hangar admin bldg, control towers parking facilities, water supply, sewage disposal plant, access roads, airways lighting, transmission and phone lines. $1,735,000.

Quito, Ecuador—Municipality, plans municipal airport. $200,000 Ebasco Services Inc., 2 Rector St., N Y.C.

Mexico City Mexico—Jose F Muguerza & Assoc. Monterrey, plans commercial airfield $8,000,000

Tampico, Mexico—Jose F. Muguerza & Assoc. Monterrey, plans commercial airfield. $500,000

Vera Cruz Mexico—Jose F Muguerza & Assoc. Monterrey, plans commercial airfield $700,000

★ COMING UP ★

May 1—2 SAE Personal Aircraft Meeting Lassen Hotel, Wichita, Kan

May 1—2 AIA Eastern Regional Traffic Committee Meeting, Hartford Conn

May 5—10 International Travel Exposition Grand Central Palace New York City

May 6 ICAO Assembly Meeting Montreal

May 8 Women's National Aeronautical Assn National Convention Los Angeles.

May 8—9 AIA Western Regional Traffic Committee Meeting Los Angeles

May 9—10 Annual Michigan Aeronautical Conference, Hotel Olds Lansing

May 9—18 Air Fair sponsored by Aviation Council of Metropolitan St. Louis.

May 11—15 American Airport Exposition & Exhibit, in conjunction with Annual Convention of American Assn. of Airport Executives, Sherman Hotel, Chicago

May 14—16 AIA Board of Governors Meeting, Williamsburg Va

May 15: IATA Technical Committee Meeting Miami Beach

May 16—22 Third International Air Service Exhibit, Utrecht, Holland

May 21: State Aviation Forum (CAA-sponsored), Charlotte N C

May 21 CAA Private Flying Forum for Mississippi, Jackson

May 22: IAS Buffalo Section Meeting, Statler Hotel, Buffalo.

May 25—June 1 Michigan Aviation Week, Detroit.

May 26—27 IAS Light Aircraft Meeting Detroit.

May 26—29 ASME Aviation Meeting Los Angeles.

May 29—June 1 Annual Mississippi Air Tour (sponsored by Jackson Chamber of Commerce).

May 30—31 Philadelphia Air Races Northeast Airport, Phila.

May 30—June 1 National Intercollegiate Flying Club-Sponsored Air Meet, Ann Arbor Mich

June 1—5 Aviation Writers Assn Annual Convention, Los Angeles

June 1—6 SAE Summer Meeting, French Lick Springs Hotel French Lick Ind

June 2 AIA Export Committee Meeting Los Angeles.

June 2—4 NAA Annual Meeting Ft. Worth, Tex.

June 3—4 AIA Personal Aircraft Council Meeting Los Angeles

June 4—6 Aero Medical Assn 18th Annual Meeting, Hotel Ritz-Carlton, Atlantic City.

June 7—8 15th Annual National Air Carnival Sponsored by Birmingham Aero Club, Birmingham, Ala.

June 17 ICAO South American Regional Air Traffic Control Meeting Lima. Peru

July 3—6 International Air Races, Long Beach Cal., sponsored by Chamber of Commerce

July 4—20 14th Annual National Soaring Meet Wichita Falls Tex

July 15 ICAO South Atlantic Regional Air Traffic Control Meeting Rio de Janeiro

July 16 State Aviation Forum (CAA-sponsored), Columbia, S C.

Aug 7—8 IAS Annual Summer Meeting Los Angeles Cal

Aug 7—9 National Flying Farmers Assn 1947 Convention, Oklahoma A&M College Stillwater

Aug 21—22 SAE West Coast Transportation & Maintenance Meeting, Biltmore Hotel, Los Angeles

Sept 2 National Air Races for lightplanes sponsored by Goodyear, Cleveland

Sept '47 ICAO Southeast Asia Regional Air Navigation Meeting (India)

Oct. 2—4 SAE Autumn Aero. Meeting, Biltmore Hotel, Los Angeles

Oct. 24—26 Air Day In Texas, Harlingen

Nov 1—9. National Aircraft Show sponsored by AIA Navy Pier, Chicago

Nov 4—7. Nation Airport Show & Institute, Municipal Auditorium sponsored by Air Foundation and National Aeronautics Assn Cleveland

Dec. 1—3 SAE Air Transport Meeting Hotel Continental, Kansas City, Mo

PATENT LISTINGS

Following are selected listings of some of the more interesting patents on aviation developments granted through the U. S. Patent office. Printed copies of any of these patents are obtainable directly from U. S. Patent Office, Washington, D. C., at a cost of 25¢ each

Self-Locking Clip, 2,416,517, filed July 24, '44, pat. Feb 11 '47, E. M. Morehouse, assignor to Adel Precision Products Corp

Attitude Indicator, 2,416,767, filed March 28 '46, pat. Feb 11, '47 C F Savage, assignor to General Electric Co

Tube Flaring Tool, 2,416,932, filed Sept. 1, '44, pat Feb 18, '47, O C Helgeson

Floorless Cargo Craft, 2,416,976, filed Aug. 7, '43 pat Feb 18, '47, R. M. Thomson

Tube Clamp, 2,416,068, filed June 11, '46, pat. Feb 18, '47, E P Nicholls, assignor to Bendix Aviation Corp

Tailless Airplane, 2,416,269, filed Sept 24, '42, pat. Mar 4, '47, W R. Sears, assignor to Northrop Aircraft, Inc

Pitch Change Aircrew Hub, 2,417,663, filed Sept. 28, '46 pat Mar 4, '47, D R MacAlpin, assignor to Bell Aircraft Corp

Aircraft Attitude Control, 2,416,429, filed Feb 13, '42, pat. Feb 11, '47, G N Henson and T W Kenyon, assignors to Sperry Gyroscope Co

Helicopter Rotor Drive, 2,416,684, filed Oct. 13, '45, pat. Feb 11, '47, V P Fleiss

Helicopter Antitorque System, 2,416,622, filed Jan 18, '44 pat Feb 11, '47, E. Bossi

Turbine Temperature Control, 2,416,673, filed Oct 16, '44 pat. Feb 11, '47 J R Campbell and A. G Swenson, assignors to General Electric Co

Supercharger for Engine and Cabin, 2,415,713, filed Nov 11 '44 pat. Feb 11, '47, C G Talbot, assignor to General Electric Co

Gun Turret, 2,415,667, filed Feb. 4, '42, pat. Feb 18, '47 G W Penthus, III assignor to Bendix Aviation Corp

Deicing Paint, 2,416,169, filed Oct 20, '46, pat Feb 18, '47, G T Lampton, H. L. Vanbinder, and T A Dissel, assignors to United Aircraft Corp

Sparkplug Design, 2,416,107, filed Mar 28, '45 pat Feb 18, '47 F B Litton, assignor to Bendix Aviation Corp

Cowl Fastener, 2,416,873 filed June 24, '44 pat. Mar 4 '47, A. M Gorfin

Flush-Type Door Latch, 2,416,862, filed Feb. 2 '44 pat. Mar 4, '47, W R Andrews assignor to Harlwell Aviation Supply Co.

Boundary Layer Suction Device, 2,416,661, filed Aug 12, '43 pat Mar 4, '47 A A. Griffith, assignor to Rolls-Royce Ltd

Electrical Connector, 2,416,866, filed Oct 10 '44, pat Feb 25 '47, J C Macy, assignor to Aircraft-Marine Products, Inc.

Aircraft Control Mechanism, 2,416,376 filed July 14, '44 pat Feb 25 '47, K. L. Gunyward

Torque Balancer for Turbojet, 2,416,391, filed July 26 '43 pat. Feb 25, '47, F A M Heppner J D Voce, and D R. Evans, assignors to Armstrong Siddeley Motors, Ltd

Variable Pitch Propeller, 2,416,516 filed Aug 20, '20 pat Feb 25, '47, W W Everts, assignor to Everel Propeller Corp.

Parachute Load Release, 2,416,668, filed July 13 pat. Feb 25, '47, S Glendon.

Conduit Flexible Joint, 2,417,266, filed Apr 17 '45 pat Mar 11 '47, G. W. Harvey, assignor to Solar Aircraft Co

"Airworthiness"

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1 Before shipment, EVERY BATCH of Glidair Aircraft Finishes is tested in the laboratory to assure correct viscosity and high solids for uniform spraying consistency and highest possible "build."

2 A sample of EVERY BATCH of clear dope is brushed out on fabric to assure controlled penetration, proper drying rate and smooth tautening action

3 A sample of EVERY BATCH of pigmented dope is sprayed out on fabric to assure its workability, hiding power and smooth flow.

THE GLIDDEN COMPANY
AVIATION SALES HEADQUARTERS
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SUPPLY DIVISION, INC. 229 E. Madison Ave., Memphis, Tennessee
SERVAIR INC. City Airport Detroit, Mich.
PIEDMONT AVIATION INC. Winston-Salem N. C.
SOUTHWEST AIRMOTIVE COMPANY Love Field, Dallas, Texas
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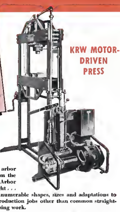
KNIPP AVIATION INDUSTRIES Pimlico Airport, Baltimore, Md.

GLIDAIR FLYING COLORS

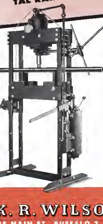
Made by **Glidden** • *Pacemaker in Paints*

Save time ON PRESSING, BENDING, STRAIGHTENING WITH A KRW HYDRAULIC ARBOR PRESS

INDISPENSABLE IN ANY SHOP ... HANDLES SHORT-RUN PRODUCTION WITH LOW-COST DIES ... AVAILABLE IN 25 TO 75-TON CAPACITIES, EITHER HAND-OPERATED OR MOTOR-DRIVEN, WITH VERTICAL OR HORIZONTAL RAM TRAVEL.



KRW MOTOR-DRIVEN PRESS



KRW HAND-OPERATED PRESS

The old conception of an arbor press is as different from the modern KRW Hydraulic Arbor Press as day is from night ... now they are built in innumerable shapes, sizes and adaptations to work on hundreds of production jobs other than common straightening, bending and pressing work.

They are available as speedy Hand-Operated Presses, highly flexible Air-Operated Presses or as versatile and effortless Motor-Operated Presses. Then too, they are built in almost any conceivable physical form ... tall, short, narrow, vertical or horizontal standing, as gap presses, forming brakes and many other designs. Mass production in a modern plant keeps KRW prices at rock bottom and quality at the highest possible peak. Write for the KRW illustrated Press Catalog. Mail the coupon for your copy now.

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KRW Hand-operated Presses ☐
KRW Air-oil Operated Presses ☐
KRW Motor-Driven Presses ☐

Name________________
Address________________
City and Zone________________State________

What's New

(Continued from page 15)

Mfg. Co., Kansas City, Mo. Solvent is stated to dissolve and disperse all petroleum residues, including lacquer, varnish, and sludge, leaving metal clean and ready for re-use. Part to be cleaned is submerged in warm solvent, agitated, and then flushed with warm water. It leaves a protective film against rust.

Aircraft Generator 18

Operating over a speed range of 3,000 to 8,000 rpm. and designed to meet requirements of high performance aircraft, new 300-amp. 30v d.c. generator is available from **Westinghouse Electric Corp.,** Lima, Ohio. Unit is compensated with both interpole and pole-face windings to make possible overload capacity and commutation properties. A quick-disconnect mounting flange facilitates installation. Frame is of 8½-in. dia., and overall length is 14 17/32 in. Weight is 98 lb.

Flexible Gas Tanks 18

Designated as "Pliocel", flexible gas tank announced by **Goodyear Tire & Rubber Co.,** Akron, is made of Nylon fabric sprayed with a solution of Nylon to increase its resistance to passage of highly volatile fuels. More crash resistant than metal tanks because of flexibility, new tank weighs .08 lb./sq. ft. of surface. New tanks are normally installed by slipping them into place in the wings or fuselage through small access doors, unfolding them inside, then snapping into place by glove type fasteners. Cells are now being made in sizes ranging from 5 to 500 gal. They can be made in a variety of shapes and can be used for both gasoline or oil.

Bench Filer 20

DoALL Co., Des Plaines, Ill., announces new and larger model FH-10 bench filing machine for filing, sawing, and honing operations. Machine incorporates patented universal joint clamp to assure vertical file position despite warped or twisted file shanks. A file-setting square is supplied for

aligning tools before universal joint is tightened, and an overarm backup roller gives support to tool. Tilting table is 10⅝ in. square. Machine has a 1½-in. stroke and a file shank capacity of ⅛ to ⅜ in. Tools are actuated by a scotch yoke mechanism running in oil. Window in housing shows

level of oil Vertical shaft bearings are adjusted by locking thumb screws on outside of housing A Neoprene bellows keeps chips out of mechanism and provides air jet to remove chips at point of work Unit is powered by a ¼-hp 110v 1,724-rpm. a.c. motor, which provides about 350 strokes per min Standard equipment includes files, saw, and honing stone Illuminated magnifying attachment and diamond hones are also available for use with unit

Heat-Proof Paint 21

Applications in aviation industry are seen for new heat-proof paint developed by **Markal Co.**, Chicago as a protection against corrosion and scale at high temperatures. It is stated to prevent hot metals from corroding and scaling at temperatures as high as 1,850 deg and to provide protection to metals in all weather conditions Maker says hot metal can be subjected to sudden changes, such as quenching in cold water, without cracking or peeling since paint follows contraction and expansion of metal at all temperatures It can be subjected to these high temperatures immediately after drying period of about 20 min.

Electric Paint Sprayer 22

Made by **Lowell Mfg Co**, Chicago, "Thoro-Spray", new electric sprayer, handles paint varnish, enamel, lacquer, and stain. It can also be used to spray oil on intricate parts of motor and other operating mechanisms Power is supplied by a 110-120v a c-d.c universal electric motor which incorporates a built-in compressor developing 22 lb of free air Nozzle is of adjustable spray-varying type Sprayer also has adjustable strap making it possible to carry over shoulder Jar has capacity of 24 oz, and total weight of unit is 8 lb

Information Tips

New Alloy 23

Information is available from **Elgin National Watch Co.**, Elgin, Ill, on new metal alloy 'Elgiloy' which is expected to find application in manufacture of jet propulsion and gas turbine parts, valve parts and electronic equipment These prime featues are reported Rust resistance of 100%, resistance to all ordinary chemicals, ability to function without setting, ability in spring form to deliver constant power over long periods of time, nonmagnetic properties and superior physical properties

Rubber Mountings 24

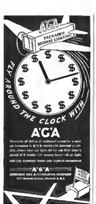
Information is offered by **Lord Mfg Co.**, Erie, Pa on 'Multiplane' rubber mountings for isolating vibrations from all directions Units are suitable for use on instrument panels and electronic equipment.

Flexible Hose and Fittings 25

Emphasizing importance of engineering research, and development in manufacture of flexible hose and fittings brochure 'Prospecting for Perfection" from **The Weatherhead Co.**, Cleveland, shows work done to develop company's products

Heat Resistance of Alloys. 26

Literature discussing influence of minor elements on heat resistance of



standard alloys has been recently translated from German and is available from **Cerium Metals Corp.**, New York City

Rivet Data 27

B. F. Goodrich Co., Akron, has published fourth edition of its data book on Rivnut one piece blind fasteners giving description of construction of regular and special types, listing sizes, dimensions, and grip range identifications, and detailing installation methods and tools.

Welding Training 28

"Learning to Weld", new booklet issued by **Lincoln Electric Co.**, Cleveland, teaches fundamentals and gives information on applying arc welding to repair of broken parts, on hard surfacing of worn parts, and building of miscellaneous equipment. Charge is made of 25c. per copy.

Pressuregraph 29

Application is seen in testing internal combustion engines and jet engines and in fuel studies for "Syncro-Marker" pressuregraph, new electronic device made by **Electro Products Laboratories**, Chicago. Device transmits to screen of cathode ray oscillograph a picture of pressure variations related to time and speed indicators.

Painting Aluminum 30

Information is available from **Technical Processes Div., Colonial Alloys Co.**, Philadelphia, on "Prepaint", material to be applied to aluminum and its alloys which are to be painted in high production. Firms are invited to submit specimens of aluminum parts or assemblies for treatment with this material for subsequent painting.

Parts Cleaner 31

Stated to be especially efficient in cleaning aircraft engine parts, new "Formula 555" degreaser and decarbonizer is announced by **Kelite Products, Inc.**, Los Angeles.

Brazing Flux 32

All-State Welding Alloys Co., White Plains, N. Y., announces availability of new brazing flux for use with sheet aluminum. Flux is stated to have a melting point in neighborhood of 950 deg.

Chamfering Machines 33

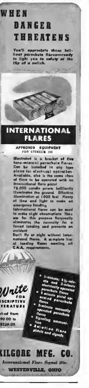
Color booklet from **The Cross Co.**, Detroit, contains diagrams and specifications explaining No. 60 series chamfering machines developed for pointing and chamfering spur, helical, and bevel gears. It will also handle splines.

Alloy Machine Parts 34

Bulletin No. 57A issued by **Ampco Metal, Inc.**, Milwaukee, entitled "Ampco Metal in Machine Parts," lists range of machine parts made of this aluminum bronze alloy and incorporated into typical machine tools.

Vertical Sensitive Tube 35

Adaptable to applications in instrument and industrial control fields, new control device, "Convectron," a vertical sensitive tube made by **Eclipse-Pioneer Div., Bendix Aviation Corp.**, Teterboro, N. J., is a Y-shaped gas-filled tube stated to be capable of giving an appreciable signal relative to its position about vertical. Since signal will in-



dicate displacement left or right of null, unit is adaptable for control of servo mechanisms and instruments

Small Capacitors 36

Information is available from **Sprague Electric Co.**, North Adams, Mass., on line of small capacitors in standard units with capacities ranging from 00025 to 1.0 mfd.

Manual on Relays....................37

Including information on coil resistance, voltage, contact data, sensitivity, insulation, and dimensions, manual from **Wells Sales, Inc.**, Chicago covers line of electrical relays

Thermally Sensitive Resistors 38

Having sensitivity to relatively minute temperature changes, "Thermistors" are new thermally sensitive resistors announced by **Western Electric Co.**, New York City. Offered in form of disks, rods, and beads, units have numerous basic circuit applications.

Plastic-Glass Cloth 39

Literature from **American Cyanamid Co.**, New York City, describes laminated Fiberglas impregnated with company's "Laminac" resin. Material is seen as of special interest to aircraft manufacturers in fabrication of semi-structural parts

Radio Equipment 40

Aircraft Radio Corp., Boonton, N. J., announces new line of aviation radio equipment consisting of Type 11 system (range receiver and VHF transmitter), VHF omni-directional range receiving system, and Type 17 two-way VHF equipment

Wipe-On Plastic Finish 41

Available in civilian field for first time, special wipe-on plastic finish made by **Reyam Plastic Products Co.**, Chicago, can be applied with cloth to plane wings, fuselage, propellers, and interiors. It can be used over either painted surfaces or finished metal.

Drapery Fabrics 42

Made of asbestos and glass, new fireproof drapery fabrics suitable for use in planes, are announced by **United States Rubber Co.**, New York City. Material will be produced in form of gray goods ready for dyeing and printing

Avigation Texts and Devices........43

Catalog No. W-2, issued by **Weems System of Navigation**, Annapolis, Md., describes avigation instruction courses, text books, charts, and classroom models of instruments. Also listed are such equipment as computers, protractors, plotters, avigation tables, sextants, star finders, and watches. Supplementary sheet which is included briefs several new items added since catalog came from press

Radio Manufacture 44

Folder published by **Bendix Radio Div., Bendix Aviation Corp.**, Baltimore, Md., pictorially describes manufacture of company's Flightweight aircraft radios.

Engine Analyzer 45

Sperry Gyroscope Co., Great Neck, N. Y., has released new catalog on Models D-2 and D-4 engine analyzers developed to provide continuous visual

analysis of aircraft power plants during flight. Instrument is designed to show characteristic patterns of engine vibration ignition system performance, and synchronization between magnetos and between engines.

Luminescent Materials 46

Use of luminescent materials in aviation is described in literature from **New Jersey Zinc Co.** New York City. Covered are both fluorescent and phosphorescent types of applications using luminescent pigments as paints, and including plastics, paper, printing inks, decals, silk screen paints, and porcelain.

Airport Lighting 47

General Electric Co., Ltd., London, England has issued large 48-page illustrated color brochure describing airport lighting equipment, lighting control, radio communications, radar and avigational aids, broadcast call equipment, ground traffic control, and power equipment Included is special fold-out lighting chart for major airfields.

Runway Lighting 48

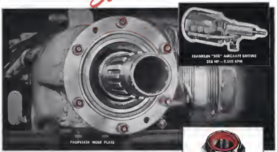
Designed for runways from 1,800 to 6,000 ft, system of runway lighting described in folder from **American Gas Accumulator Co.,** Elizabeth, N. J., operates on 230v, 60 cycle primary circuit.

Airport Scooter 49

Information is available from **McCulloch Motors Corp.,** Los Angeles, on new gasoline powered scooter for general duties around airports. It weighs 75 lb, is powered with a 4-hp engine, and has a wheel base of 38 in.

"Maguire's having trouble with his pressurization system."

SELF-LOCKING *Prestressed Settings* RESIST PROP-ENGINE VIBRATIONS

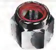


The Red Elastic Collar provides dependable protection against VIBRATION!

Two sources of vibration combine their efforts to loosen the detachable fasteners on the propeller nose plate of the Franklin "500" Aircraft Engine. Continuous engine vibration and fluctuating blade flutter, caused by turbulent air, make each prestressed setting a potential trouble spot. Conventional fasteners would shake loose. But ESNA Elastic Stop Nuts hold fast!

The reason for the dependable ESNA protection is the Red Elastic Collar that has become a symbol of security to all aviation engineers. Its full contact grip on the bolt or stud threads and its metal thread seating action make all Elastic Stop Nuts self-locking and self-sealing. As a result, they protect against Vibration, Thread Corrosion, Thread Failure and Liquid Seepage.

ESNA experience and research are always at the disposal of the aviation industry. Industrial distributors are stocked and ready to give prompt service. For further information address: Elastic Stop Nut Corporation of America, Union, New Jersey. Sales Engineers and Distributors are now conveniently located in many principal cities.



LOOK FOR THE RED COLLAR THE SYMBOL OF SECURITY

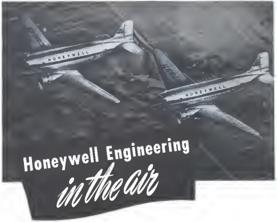
It is threadless and dependably elastic. Every bolt—*regardless of commercial tolerances*—impresses (does not cut) its full thread contact in the Red Elastic Collar to fully grip the bolt threads. In addition, this threading action properly seats the metal threads—and eliminates all axial play between the bolt and nut.

All ESNA Elastic Stop Nuts—*regardless of size or type*—lock in position anywhere on a bolt or stud. Vibration impact or stress reversal cannot disturb prestressed or positioned settings.

ELASTIC STOP NUTS

INTERNAL WRENCHING · ANCHOR · WING · INSTRUMENT MOUNTING · THIN HEX · GANG CHANNEL · CAP

PRODUCTS OF: ELASTIC STOP NUT CORPORATION OF AMERICA



Honeywell Engineering *in the air*

One for research, the other for demonstration — together these Honeywell planes represent an engineering service prepared to apply automatic control to individual aeronautic requirements.

Already widely separated applications of automatic control have furnished the answer to important achievements in the air. And to meet the varying needs of every control problem, Honeywell's engineering service includes not only the facilities for new developments but a background of experience in all fields of automatic control. Most important, Honeywell has demonstrated the capacity to apply this experience to aviation's problems.

Make full use of this highly specialized service in seeking the answers to your particular problems, no matter how complex. Write Minneapolis-Honeywell Regulator Company, 2675 Fourth Avenue South, Minneapolis 8, Minn. In Canada: Toronto 12, Ontario.

Special equipment for recording test data in flight. Six continuous control functions, such as forces applied to control surfaces and data on automatic approach patterns, are obtained. This is one of many items of special test equipment devised by Honeywell engineers for our engineering aircraft.

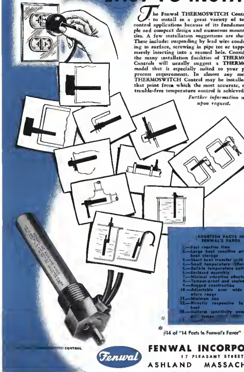
CREATIVE ENGINEERING — MINNEAPOLIS Honeywell AERONAUTICAL CONTROLS

MAKERS OF THE FAMOUS M-H ELECTRONIC AUTOPILOT, STANDARD ON ALL AAF 4-ENGINED BOMBERS

EASY TO INSTALL*

The Fenwal THERMOSWITCH Control is easy to install in a great variety of temperature control applications because of its fundamentally simple and compact design and numerous mounting facilities. A few installation suggestions are shown below. These include: suspending by lead wire conduit, clamping to surface, screwing in pipe tee or tapped hole, or merely inserting into a reamed hole. Consideration of the many installation facilities of THERMOSWITCH Controls will usually suggest a THERMOSWITCH model that is especially suited to your product or process requirements. In almost any medium, the THERMOSWITCH Control may be installed easily at that point from which the most accurate, economical, trouble-free temperature control is achieved.

Further information will be sent upon request.



FOURTEEN FACTS IN FENWAL'S FAVOR

1.—Fast reaction time
2.—Large heat sensitive area, small heat storage
3.—Short heat transfer path
4.—Small temperature differential
5.—Built-in temperature anticipation
6.—Enclosed assembly
7.—Minimal vibration effects
8.—Tamper-proof and sealed
9.—Rugged construction
10.—Adjustable over wide temperature range
11.—Minimum size
12.—Directly responsive to radiant heat
13.—Uniform sensitivity over adjust... temperature...

*#14 of "14 Facts in Fenwal's Favor"

FENWAL INCORPORATED
17 PLEASANT STREET
ASHLAND MASSACHUSETTS
Thermotechnics for Complete Temperature Regulation

The Lamson & Sessions Co.
Manufacturers of
Bolts Nuts Cotters Cap Screws Aircraft (AN) Products
1971 West 85th Street
Cleveland 2, Ohio

Roy H. Smith, President
James P. Donahue, Vice President

R. O. Patterson, General Sales Manager
A. E. R. Peterka, Mgr. Aircraft Division

To the Aircraft Industry

SUBJECT: Statement of Policy

The management of this company is deeply concerned by the diversion of too great a number of America's aircraft production facilities into other channels. While such diversion is currently economically sound it must not be carried to the point where it might jeopardize our national security.

The Lamson & Sessions Company is determined to maintain a continuing production of aircraft products. In spite of the fact that right now we could very profitably use all available equipment in the production of "standard commercial" fasteners, we have decided that a portion of our facilities shall remain allocated to the manufacture of aircraft bolts, nuts, screws and cotters.

We believe strongly in the future of the aircraft industry of the United States and wish to cooperate fully with the Aircraft Industry Association and its President, General O. P. Echols.

We want to support the defense program of the Army Air Forces and therefore are determined to keep our aircraft parts production machinery in such condition that should the need ever arise again, we could multiply our production a thousand-fold "overnight".

Supplementing this policy, and as a member of the Aviation Distributors & Manufacturers Association, The Lamson & Sessions Company urges that you support reliable established Aircraft Parts Distributors as another vital part of our Preparedness Program. Moreover, in purchasing through reliable, established Distributors you get economy and extra value in service and efficiency.

In conclusion, we want to commend the current Industry Agency program of the War Assets Administration for the disposal of surplus aircraft hardware, and offer the continued cooperation of the Lamson & Sessions Company in this important activity.

Roy H. Smith
President

you get

PRECISION ACCURACY and GREAT STRENGTH

in these UNBRAKO Reg U.S. Pat Off

SOCKET SCREW PRODUCTS

(A)

(B)

And that's why—for security in the air—more and more "Unbrako" Socket Screw Products are being specified by aircraft designers and engineers.

The "Unbrako" Internal Wrenching Bolt (A), the 100° Flush Head Socket Bolt (B), and the Internal Wreching Lock Nut (C)—an officially approved safety nut—meet the extreme degree of precision, tensile and other stringent requirements of the aviation industry.

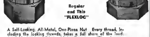
Write for your copy of the "Unbrako" Catalog of Socket Screw Products.

('C')

"Unbrako" and "Hallowell" Products are sold entirely through Industrial Distributors.

Knurling of Socket Screws originated with "Unbrako" in 1934.

FLEXLOC



'G'

PAT'D AND PATS PEND

Regular and Thin "FLEXLOC"

A Self-Locking, All-Metal, One-Piece Nut. Every thread, including the locking threads, takes a full share of the load. Available in sizes #6 to 1" in diameter—millions in use.

OVER 44 YEARS IN BUSINESS

('C')

"UNBRAKO" SOCKET SET SCREW WITH KNURLED CUP POINT

The Knurled cup point of this "Unbrako" makes it a Self Locker—the points dig in and hold fast, even when subjected to the most chattering vibration.
PAT'D AND PATS. PEND

('D')

"UNBRAKO" SOCKET SET SCREW WITH KNURLED THREADS

The Knurled threads make this screw a Self Locker, too, for Flat, Cone, Oval, One-Half and Full Dog Points.
PAT'D AND PATS. PEND

('E')

"UNBRAKO" KNURLED SOCKET HEAD CAP SCREW

The Knurled head of this "Unbrako" provides a slip and tumble proof grip, though the fingers and head be ever so oily, therefore it can be screwed-in faster and farther before it becomes necessary to use a wrench.

('F')

"HALLOWELL" KEY KIT

Kits Pats. Pend

You can't screw socket screws in or out without a hex socket wrench, so why not get our No. 25 or No. 50 "Hallowell" Hollow Handle Key Kit which contains most all hex bits.

STANDARD PRESSED STEEL CO.

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We Like Tough Jobs!

TAKE A LOOK AT THE McDONNELL PHANTOM FOR INSTANCE

HERE'S the fastest thing with wings that ever took off from an aircraft carrier's flight deck—the McDonnell Phantom!

Powered by two turbo-jet engines—streamlined to achieve a top flight speed of over 500 miles per hour—it still has the stability and control characteristics at slow landing speeds comparable to conventional carrier based planes.

This is another major development in modern aircraft in which Foote Bros. "A-Q" Gears and Power Units are playing a part.

On the axial flow turbo-jet engines the accessory drive units are produced by Foote Bros. In the wings of the Phantom, Foote Bros. actuators supply immediate response in raising and lowering speed brakes—so important in the control of this swift plane.

Manufacturers of many types of industrial equipment requiring gears of extreme precision are finding in Foote Bros. "A-Q" (aircraft quality) Gears an answer to problems of greater efficiency, higher speed, unusual compactness, light weight and low noise level.

Manufacturers of equipment requiring absolute control of operations from a remote point may find an answer in Foote Bros. Power Units and Actuators. These units are individually engineered to the job they are intended to do, and assure compactness, light weight, and, above all, positive control of linear or rotary motion within an exact time cycle. They also provide the extremely accurate mounting of "A-Q" Gears—so essential if the full benefit of their precision is to be realized.

Of course, you as well as thousands of other leading manufacturers will continue to look to Foote Bros. for industrial gears of all sizes and types and speed reducers in a wide range of ratios as you have since 1859.

Two engineering bulletins, one on "A-Q" gears, the other on Power Units, offer many suggestions on new developments in application of power. If you have not received copies, mail the coupon below.

FOOTE BROS.

Better Power Transmission Through Better Gears

FOOTE BROS. GEAR AND MACHINE CORPORATION
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Gentlemen: Please send me Bulletins on:
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Use KESTER Fluxes

• The use of wrong flux in any soldering operation means solder failure Select your flux from Kester's complete high quality line and be sure you're using the chemically and physically correct flux for your particular soldering job.

• Nearly half a century of practical experience has resulted in the development by Kester of efficient and effective fluxes for every soldering operation Proven in industry, Kester Fluxes are your assurance of clean, tight solder bonds—solder bonds that hold tight against vibration, shock, twisting, bending, and the expansion and contraction of temperature extremes.

• Each one of the hundreds of Kester fluxes has been carefully tested in the laboratory and in practical application Today, not only is the performance of each Kester flux definitely known, but also the circumstances under which each one should best be used.

• So look to Kester Fluxes for the answer to any flux problem. Without obligation to you, Kester engineers will gladly specify the flux that fits your special needs

KESTER SOLDER COMPANY
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KESTER
Solder Fluxes
STANDARD FOR INDUSTRY

Solves Many Fastening Problems • •

DILL *Lok-Skru*
Triple Duty Fastener
RIVET • ANCHOR NUT • SCREW LOCK

Blind or Visible Attachment

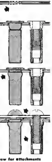
Complete Installation in Seconds

1 Drill ONE Hole

2 Insert LOK-SKRU
(Types with flat, flush, countersunk or spacer head. Sizes as required for metal thickness and hole diameter.)

3 Draw LOK-SKRU sleeve against inner side of metal with special power or hand tool, to rivet sheets securely. LOK-SKRU head, tapped for 6, 8, or 10/32 machine screw, provides an anchor nut.

4 Screw, to fasten attachments, is locked in anchor nut by tension grip.



Disassembled LOK-SKRU with screw for attachments

Write for Folder
Handy information on the many uses and application of Lok-Skrus in airplane construction with data on types and sizes

THE DILL MANUFACTURING CO.

FACTORY	BRANCH
700 East 82nd St.	1011 S. Flower St.
CLEVELAND, OHIO	LOS ANGELES, CALIF.

THE AVIATION STANDARD
for SCREW LOCKING ANCHOR NUT USES AND METAL TO METAL RIVETING

45,000 lbs. at 200 m. p. h. ...with the help of Nickel Alloy Steels

This "Flying Mail Car" with its 2916 cubic feet of cargo space shows the far-reaching advantages of using Nickel alloy steels in aircraft.

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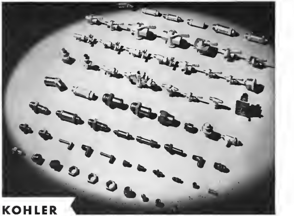

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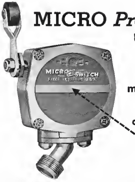

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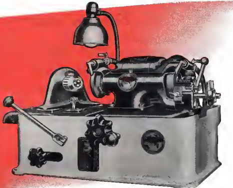

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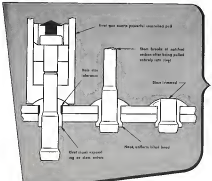

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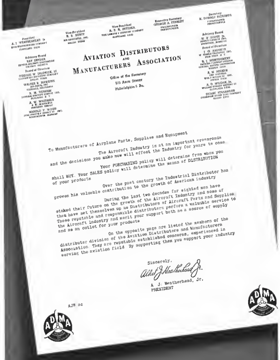

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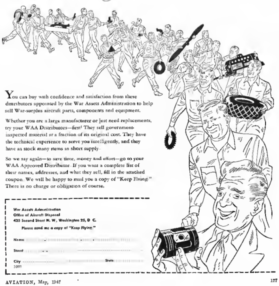

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Both Medium and VHF are at your finger tips in this LEAR Remotely Controlled TRANSMITTER

DISTRIBUTORS: Desirable territories are open

Any of six frequencies are right at hand in this Lear MVHT-6 transmitter. Two are in the medium frequency range—four in the very high frequencies.

So come what may, you're all set. Plenty of power too, with 12-14 watts in VHF and 48-55 watts in the medium frequencies. And all this in a transmitter that weighs only 30 pounds complete with cables and accessories.

MVHT-6 also includes a continuously variable antenna coupling which aids greatly in matching the transmitter to the plane's antenna precisely with a standard 50 ohm coaxial cable.

This is a transmitter that can be vitally important to you. See it at your Lear Aircraft Radio Dealer.

Quick Facts About The Lear MVHT-6

- *Combines medium and very high frequencies*
- *Covers 6210 kc., 3105 kc., 121.5 mc., 122.1 mc., 122.5 mc., 122.9 mc.*
- *Usable power, 12-14 watts VHF, 48-55 watts on medium frequencies*
- *Weight 30 pounds complete*
- *14 volt or 28 volt units available*

LEAR RADIO

The Name Men Fly By

LEAR, Incorporated, Aviation Radio Sales, 110 Ionia Avenue, N.W., Grand Rapids 2, Michigan

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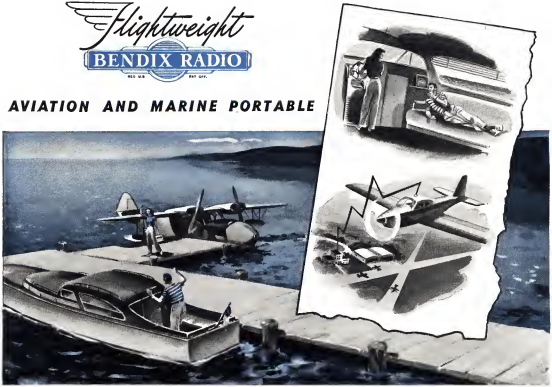
Flightweight
BENDIX RADIO

AVIATION AND MARINE PORTABLE



Entertainment plus navigation and communications

Air Marine

SPECIFICATIONS

SIZE: 6½" wide, 11" high, 12¾" long.

WEIGHT: Approximately 6 pounds (less batteries).

FREQUENCY RANGE: 3 bands; 195—410 kc.; 540—1620 kc.; 2000—5800 kc.

RANGE FILTER: Built-in for 195—410 kc. band.

POWER: Self-contained A-B power pack with 110 V. AC-DC plug in.

ANTENNA: All purpose self-contained loop for reception and direction finding on range and broadcast bands. External antenna connector also provided for all three bands.

LOUDSPEAKER: Full-size dynamic permanent magnet type.

HEADPHONES: Built-in jack connector.

CASE: Modern styling with two-tone textile leather covering and piano hinge door for complete protection of dial, speaker, jacks and controls.

At home, afloat or in the air, the Bendix FLIGHTWEIGHT portable combines the functions of an aircraft, marine and home radio receiver. Neatly compact in a modern textile leather carrying case, this 3 band sportsman's portable radio is distinctive in both design and function.

Created especially for personal planes and private boat operators by Bendix, the greatest name in aircraft radio, this handy unit brings you weather reports, navigational aids for direction finding, air and marine communications reception and regular broadcast entertainment. Powered from self contained long-life batteries or operated on 110 volts AC-DC current, this new portable is equally useful and entertaining in a plane, boat, room, at the campfire or picnic.

Ask your airport Dealer about it or write Bendix Personal Aviation Sales.

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